

*Validation of AIRS V5 TPW
(Total Precipitable Water Vapor)
at the ARM Southern Great Plains
and Tropical Western Pacific Sites*

[Climate Quality Assessment of AIRS TPW]

Robert Knuteson,
Dave Tobin, Sarah Bedka,
Dave Turner, Hank Revercomb

University of Wisconsin-Madison
Space Science & Engineering Center
Cooperative Institute for Meteorological Satellite Studies

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AIRS V5 Climate Quality Assessment of Total Precipitable Water (TPW)

Objectives:

- The AIRS Level 3 monthly TPW product has a diurnal bias which shows both a seasonal and geographic variation. Is this **diurnal monthly bias** real or a retrieval artifact?
- Assess the **absolute accuracy** of the AIRS Level 2 TPW at reference sites on a field of regard basis over the full range of total water amounts using validation measurements that have known absolute accuracy with significant numbers of statistical samples.

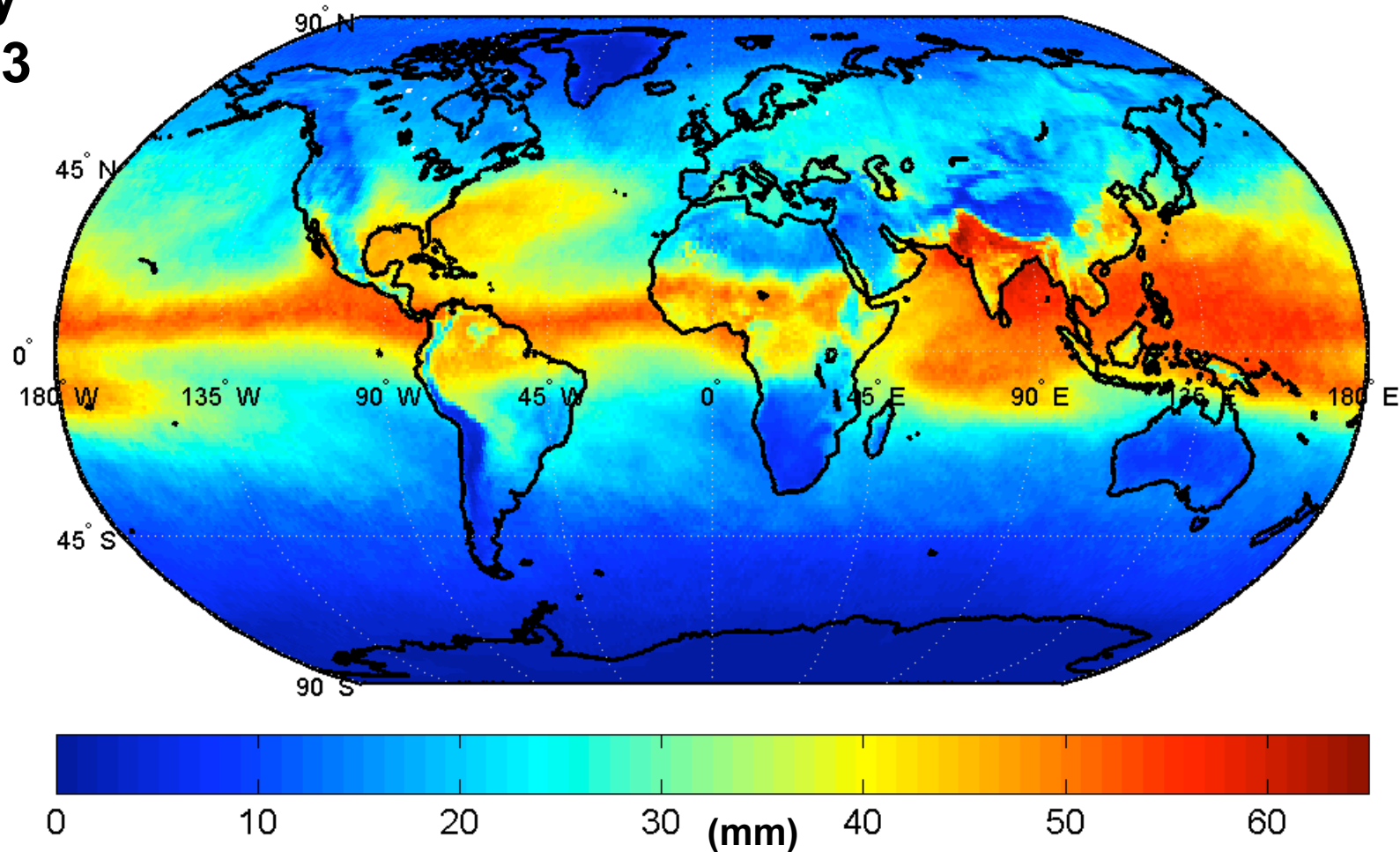
AIRS V5.0

EOS AQUA Water Vapor

DAY

July
2003

AIRS Total Water Vapor DAY (mm H₂O): July 2003



- Monthly gridded products (L3) are often used in climate studies. What is the accuracy of the AIRS L3 TPW product?

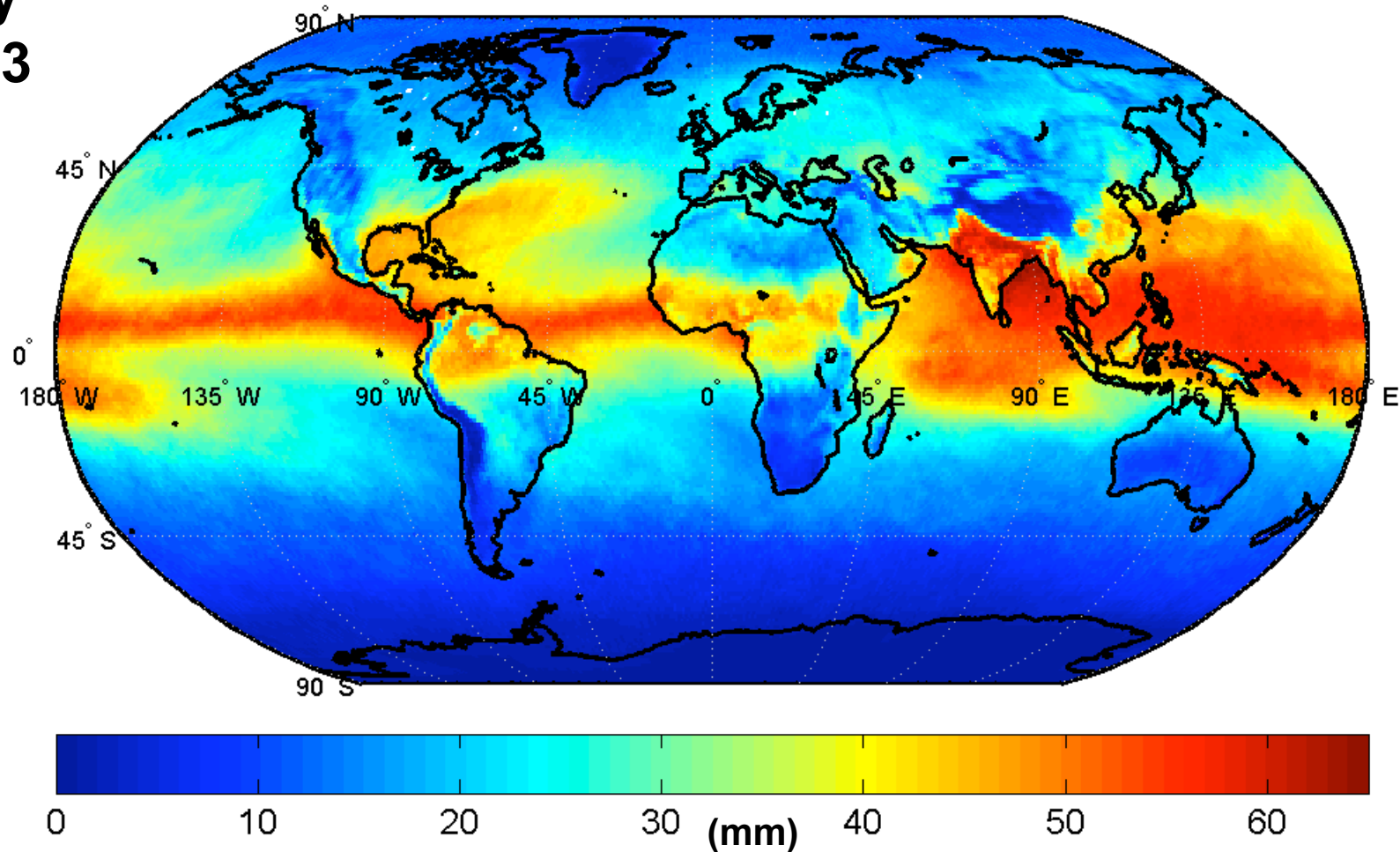
AIRS V5.0

EOS AQUA Water Vapor

NIGHT

**July
2003**

AIRS Total Water Vapor NIGHT (mm H₂O): July 2003



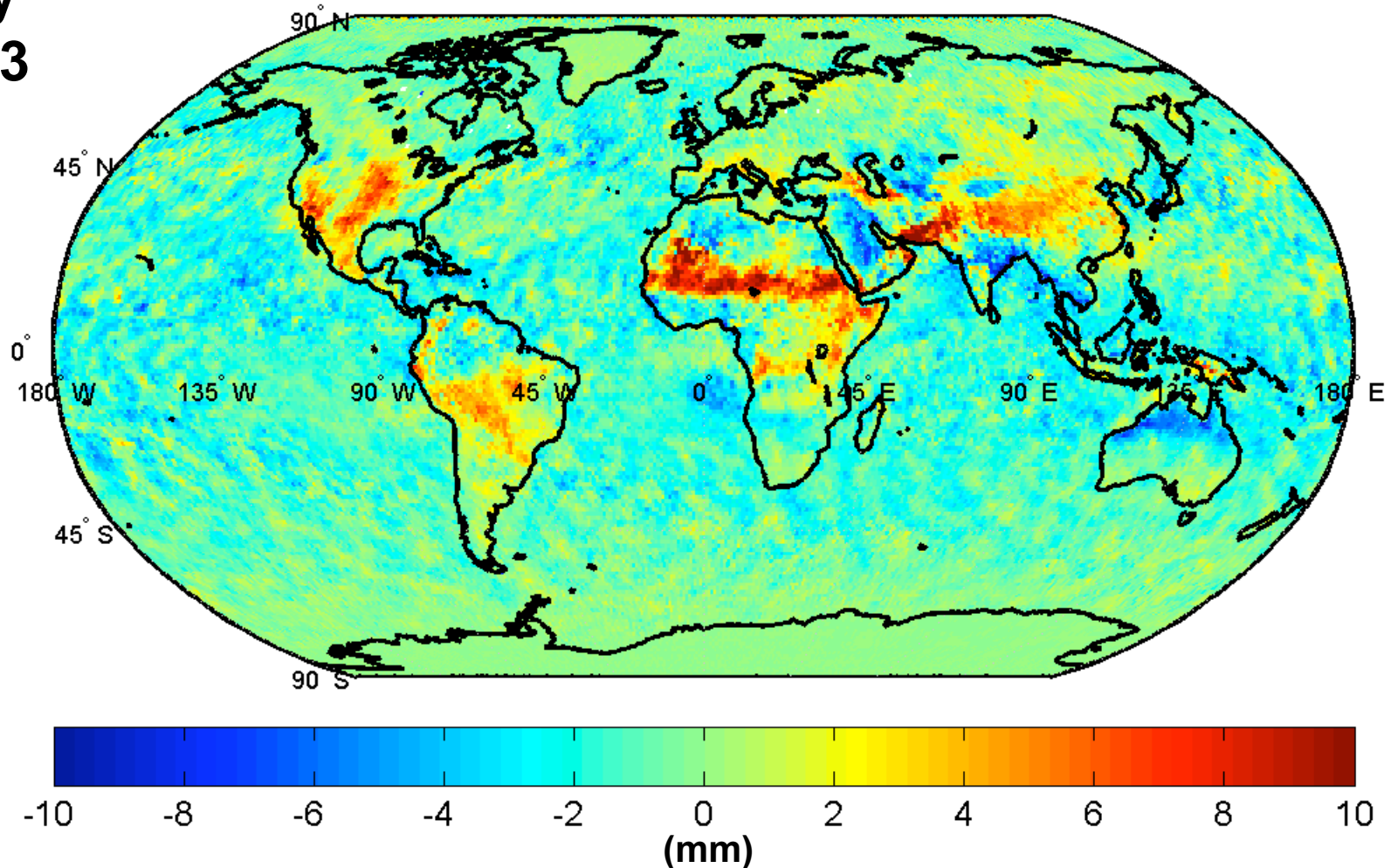
- AIRS Level 3 monthly TPW product accumulates ascending (Day) and descending (Night) separately. Do monthly means agree?

AIRS V5.0

Day - Night

July
2003

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): July 2003



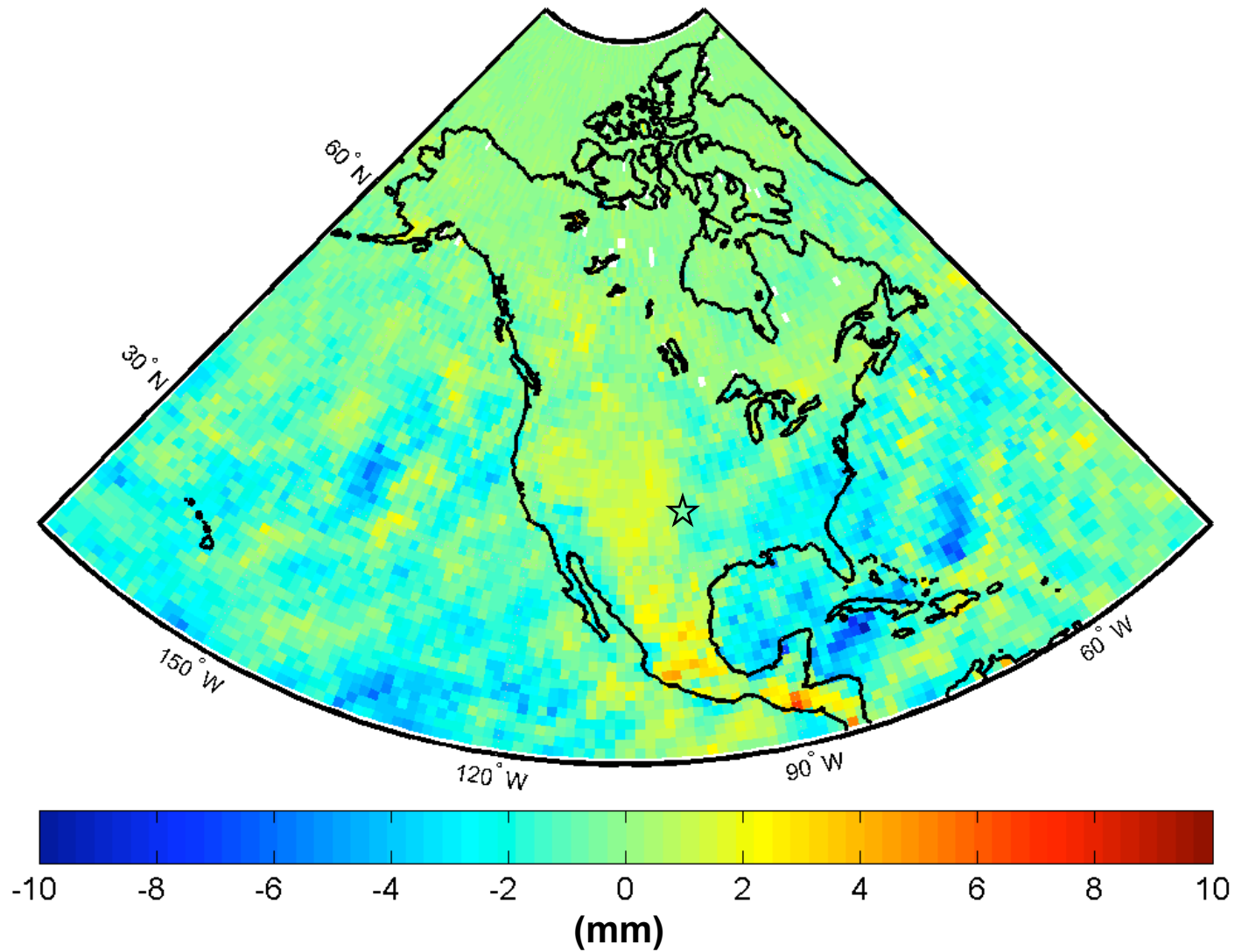
- Are AIRS Day/Night water vapor profile retrievals being impacted by retrievals over land, i.e. a surface emissivity error?
Look more closely at the U.S. Great Plains and the ARM site there.

AIRS V5.0

January 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.01

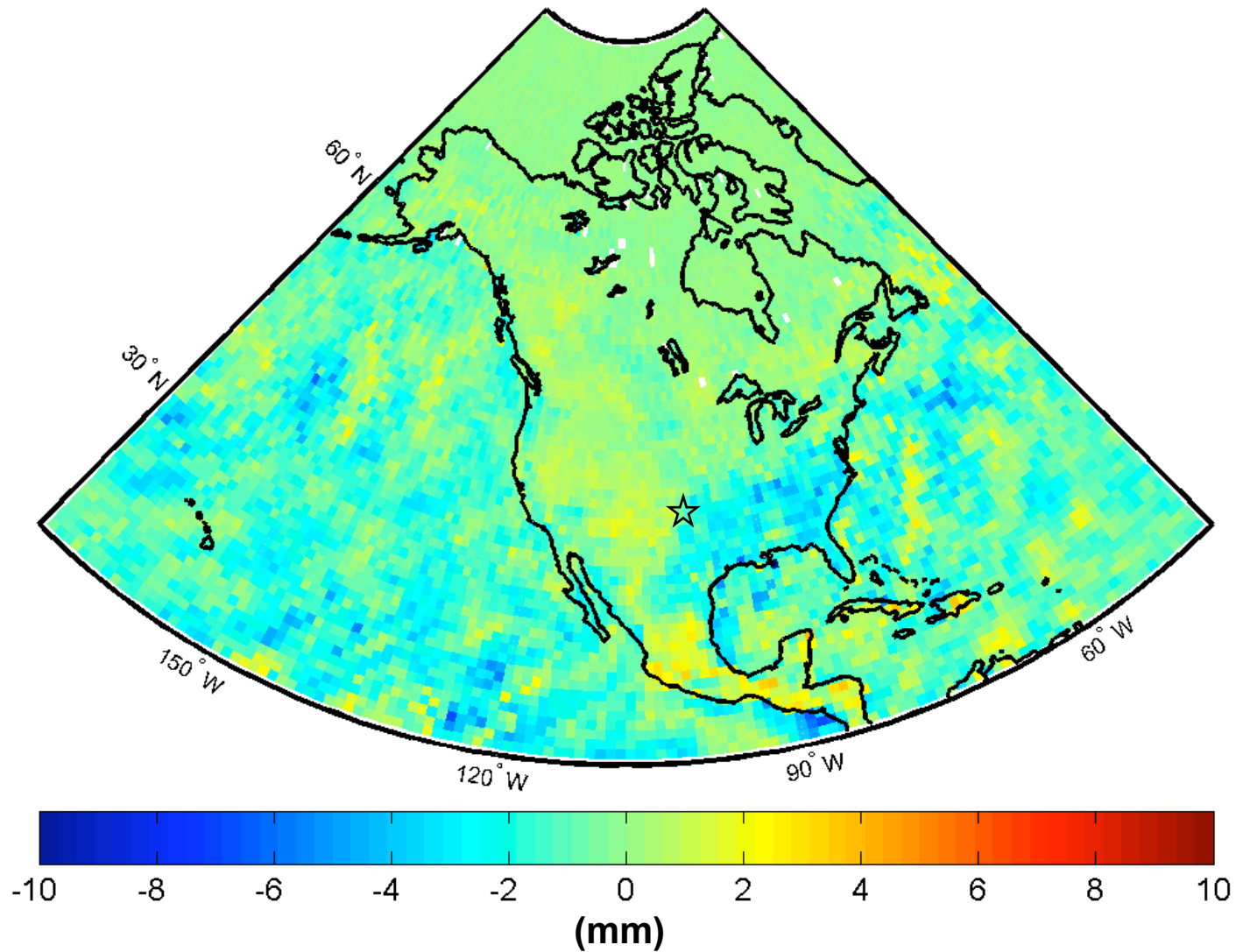


AIRS V5.0

February 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.02

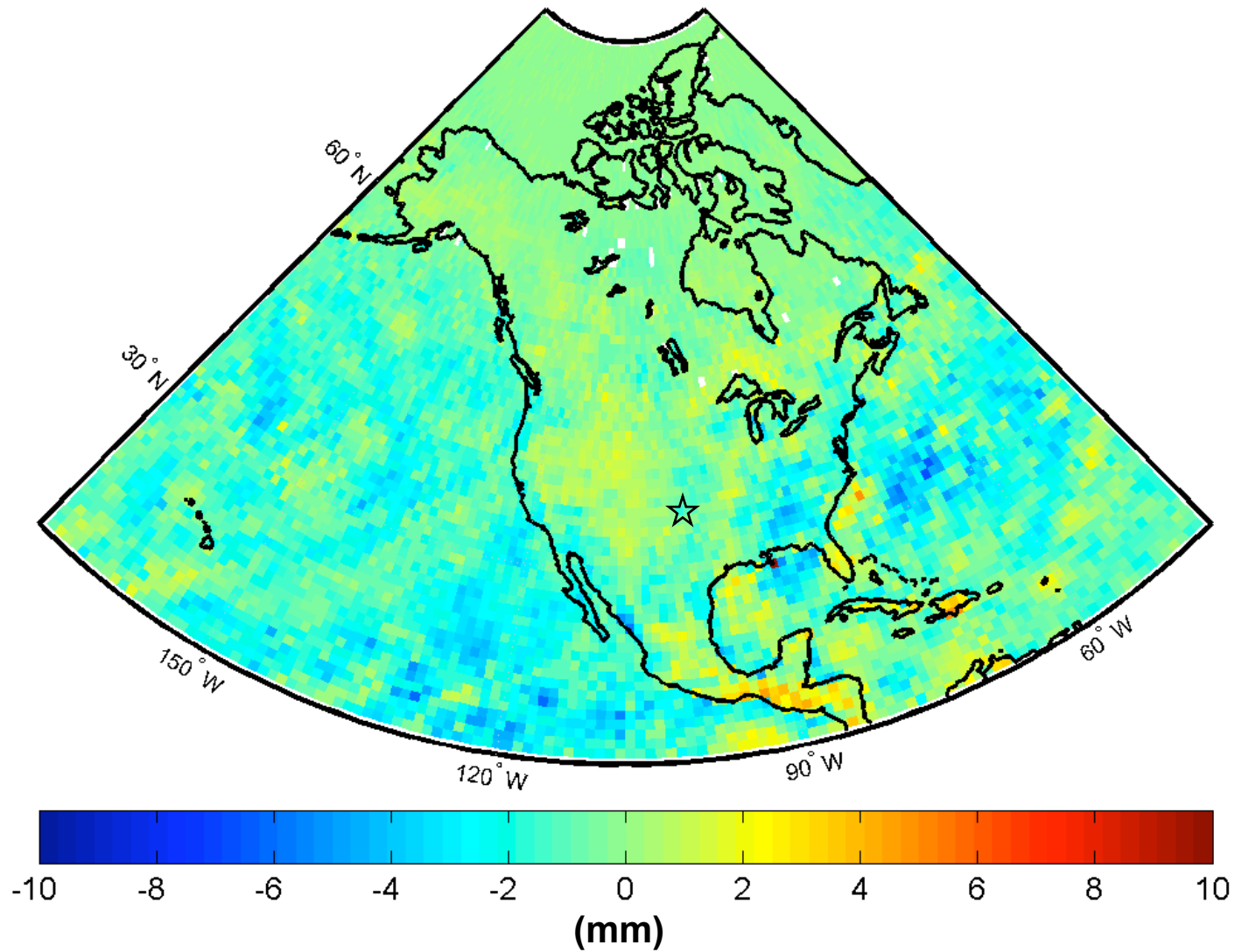


AIRS V5.0

March 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.03

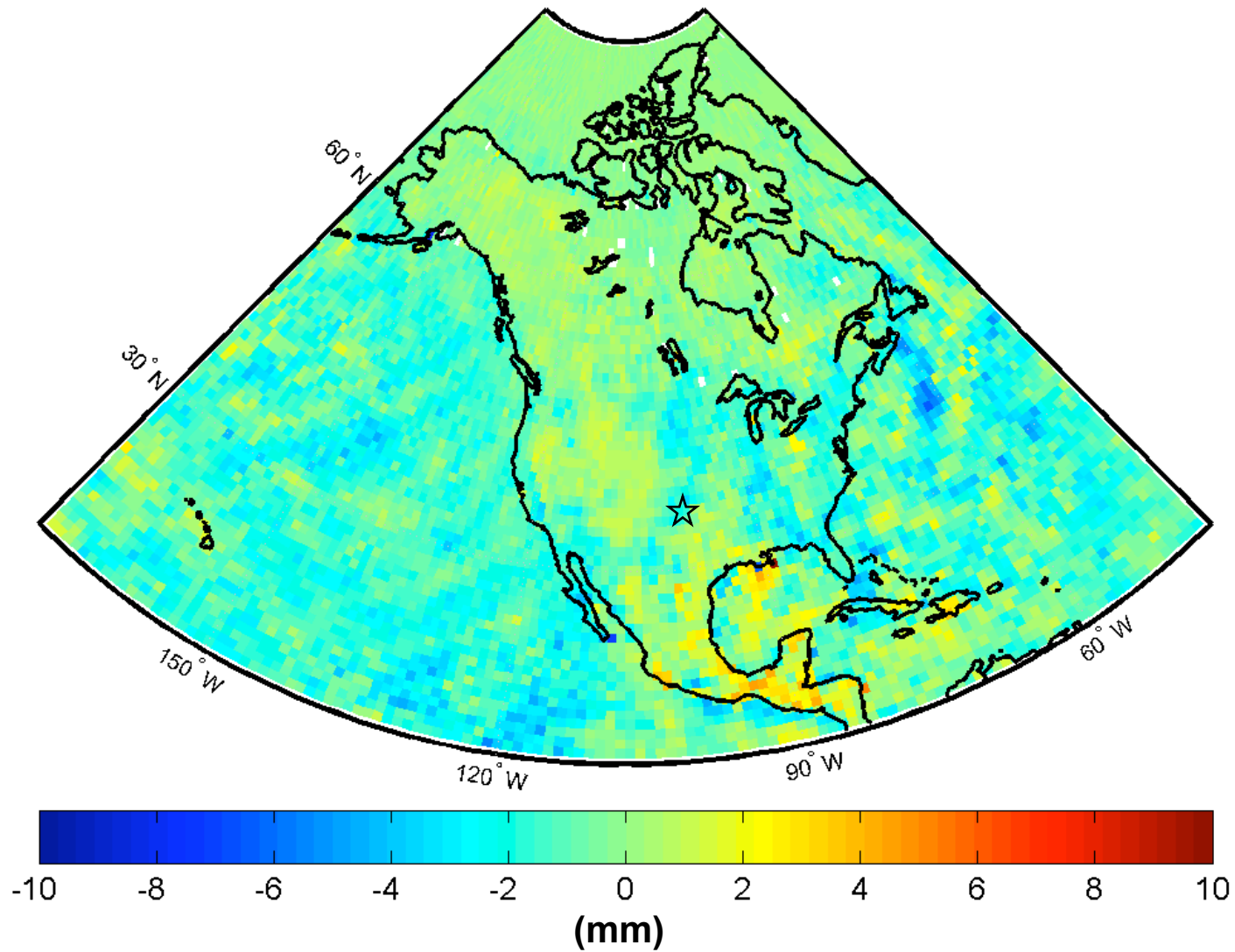


AIRS V5.0

April 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.04

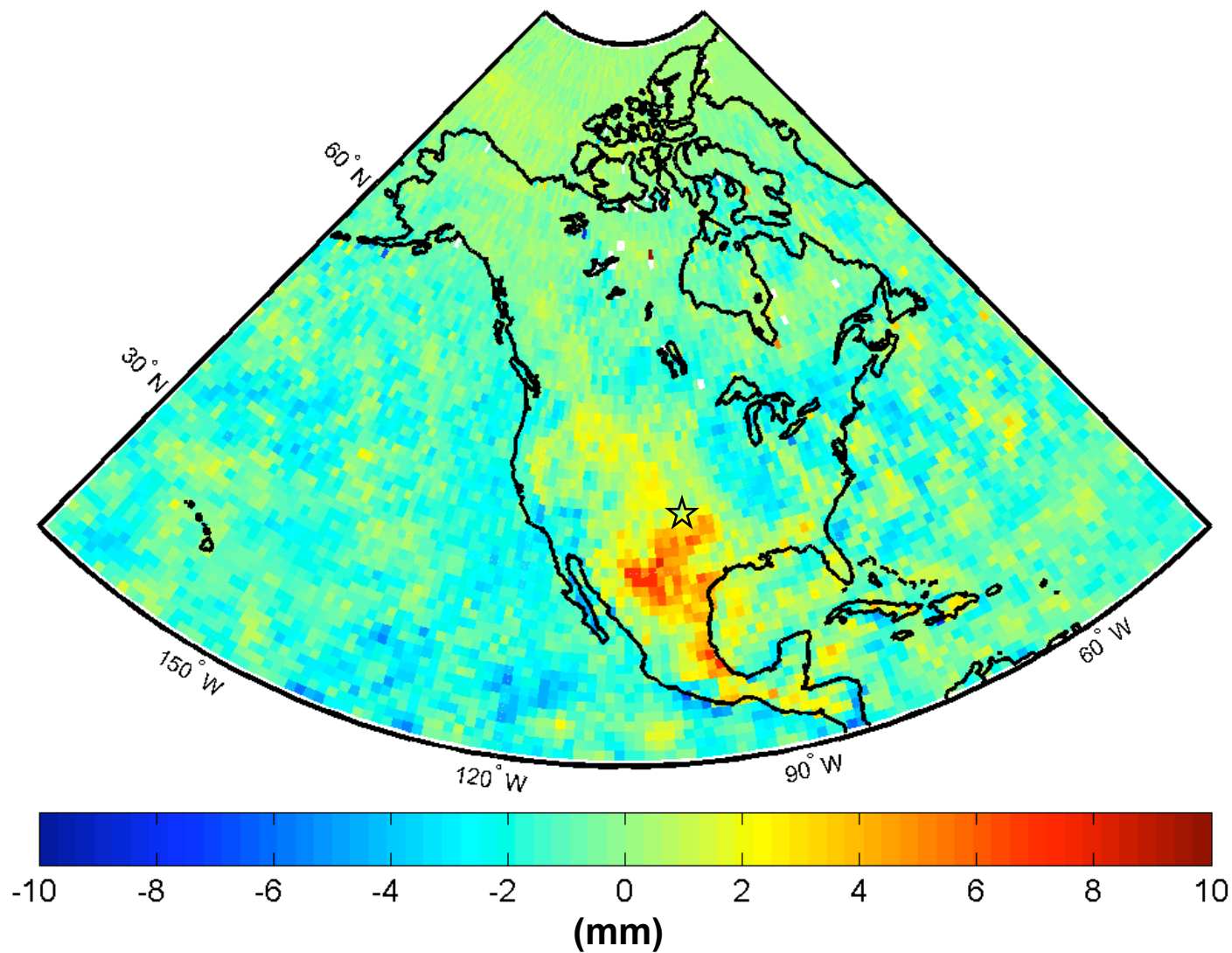


AIRS V5.0

May 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.05

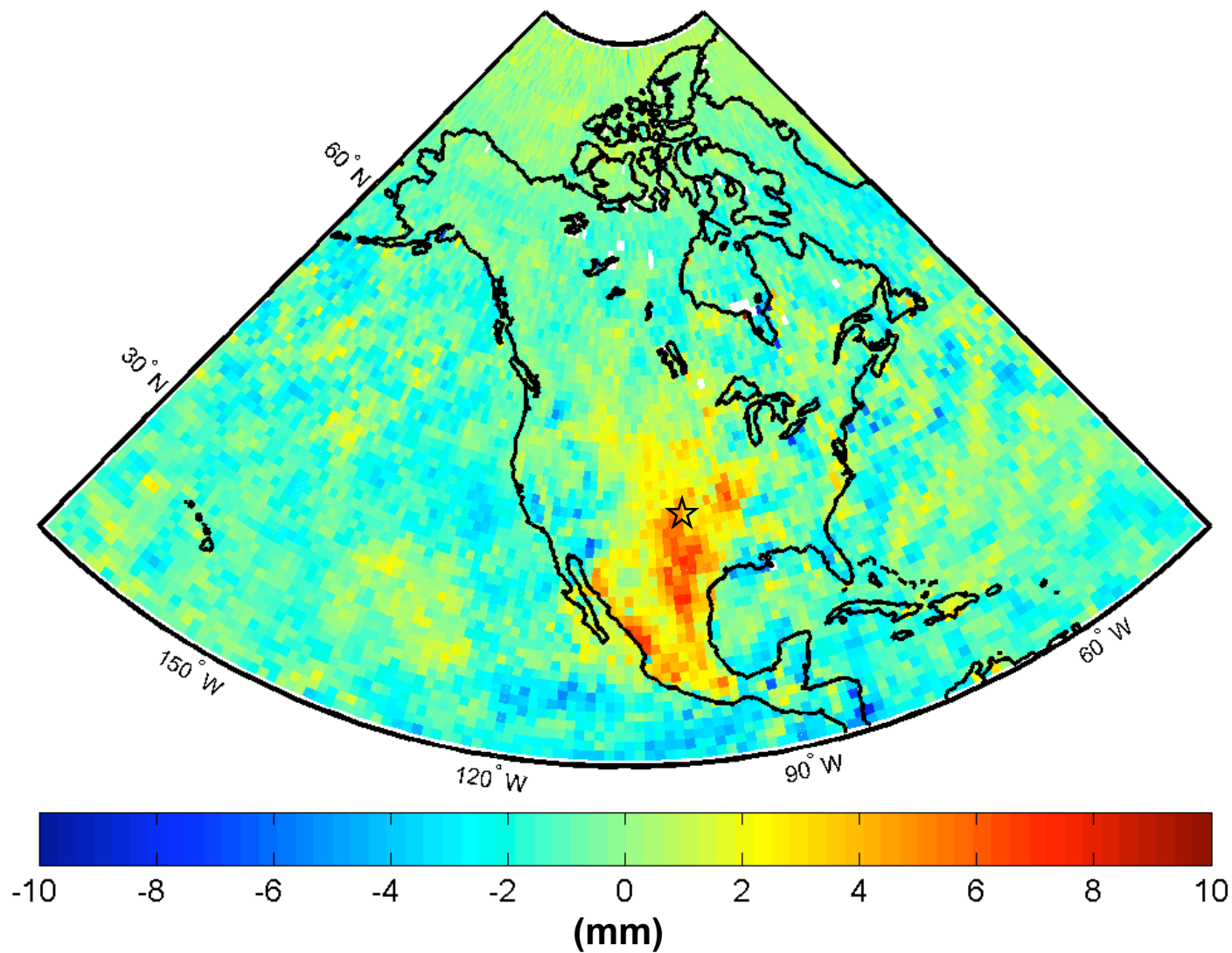


AIRS V5.0

June 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.06

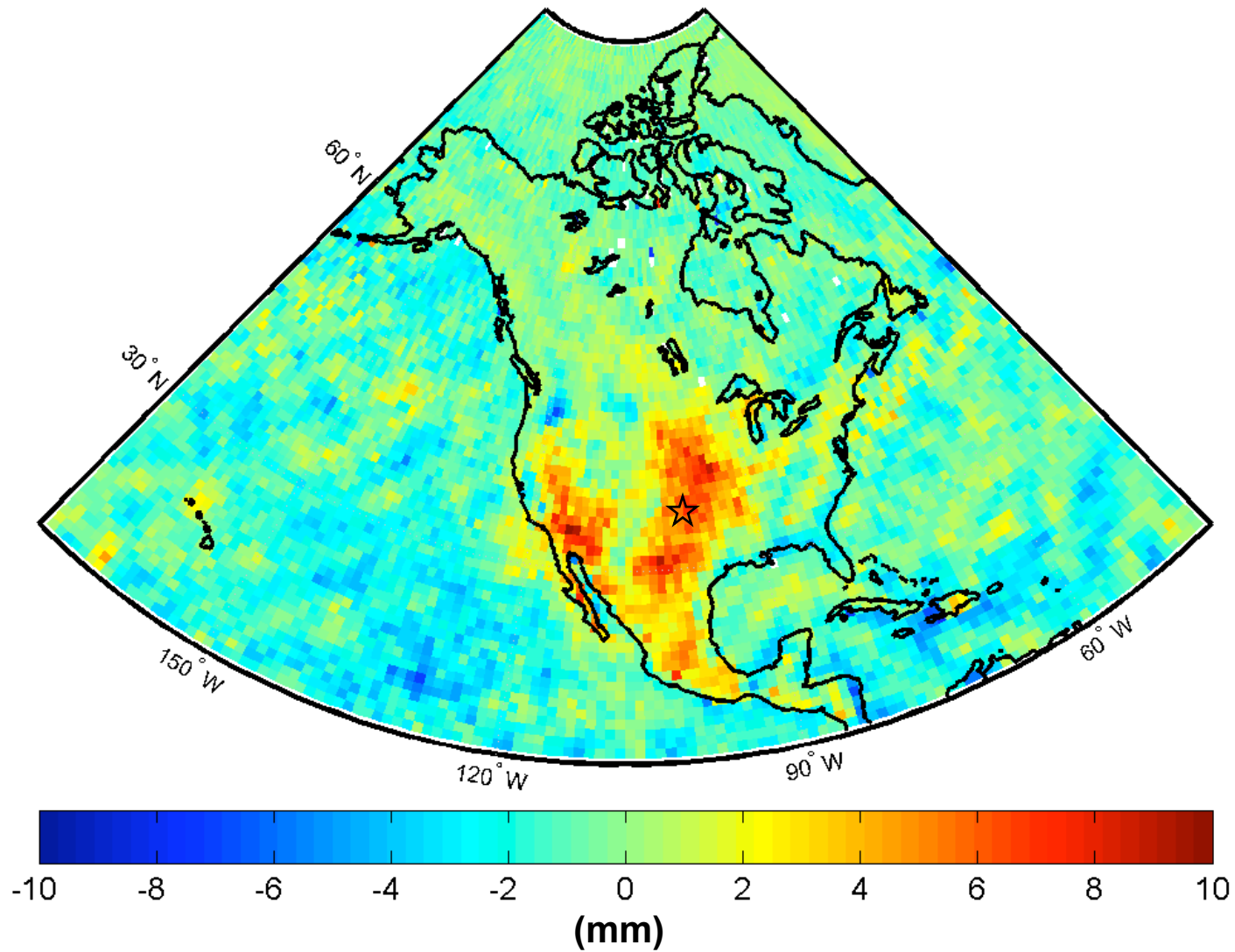


AIRS V5.0

July 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.07

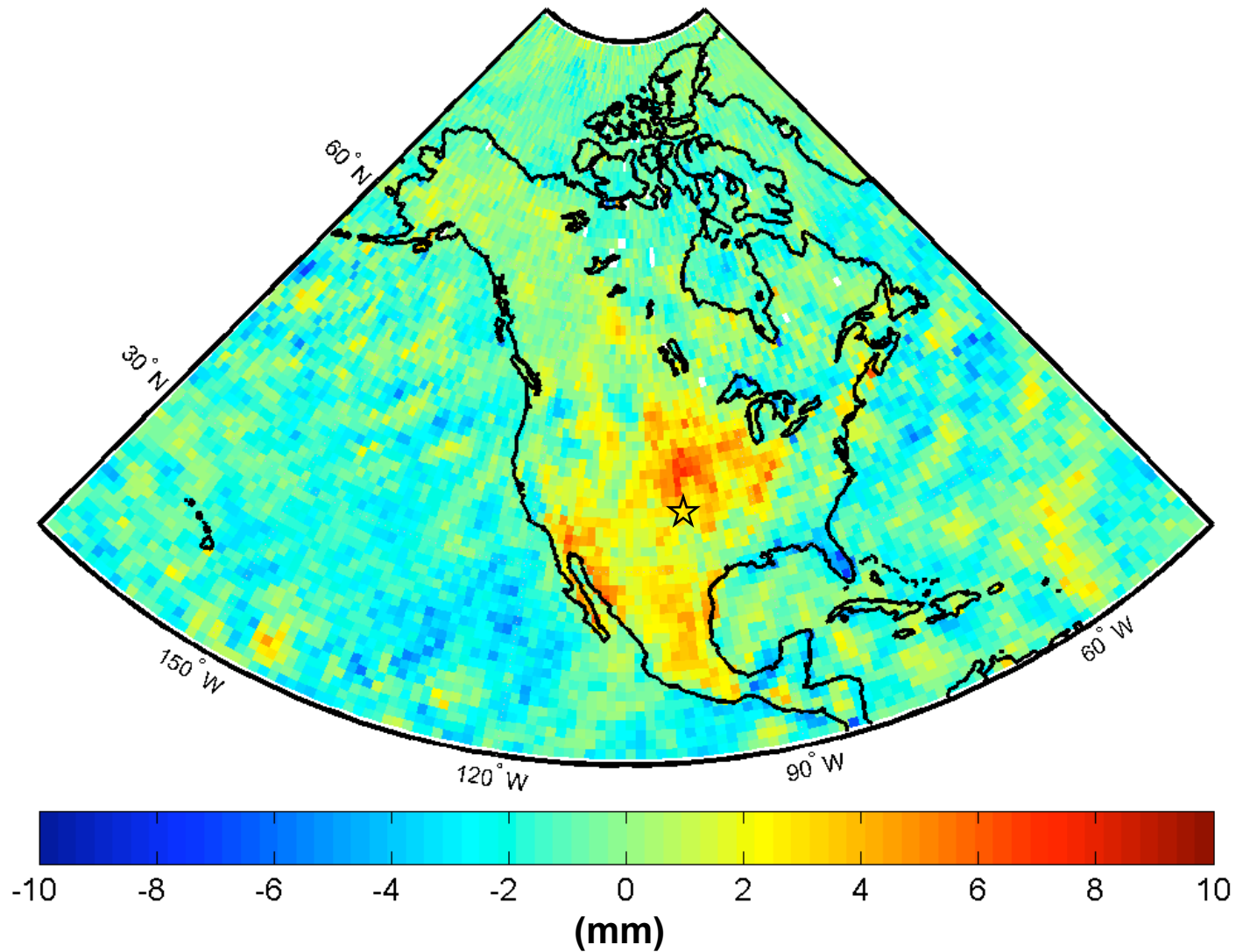


AIRS V5.0

August 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.08

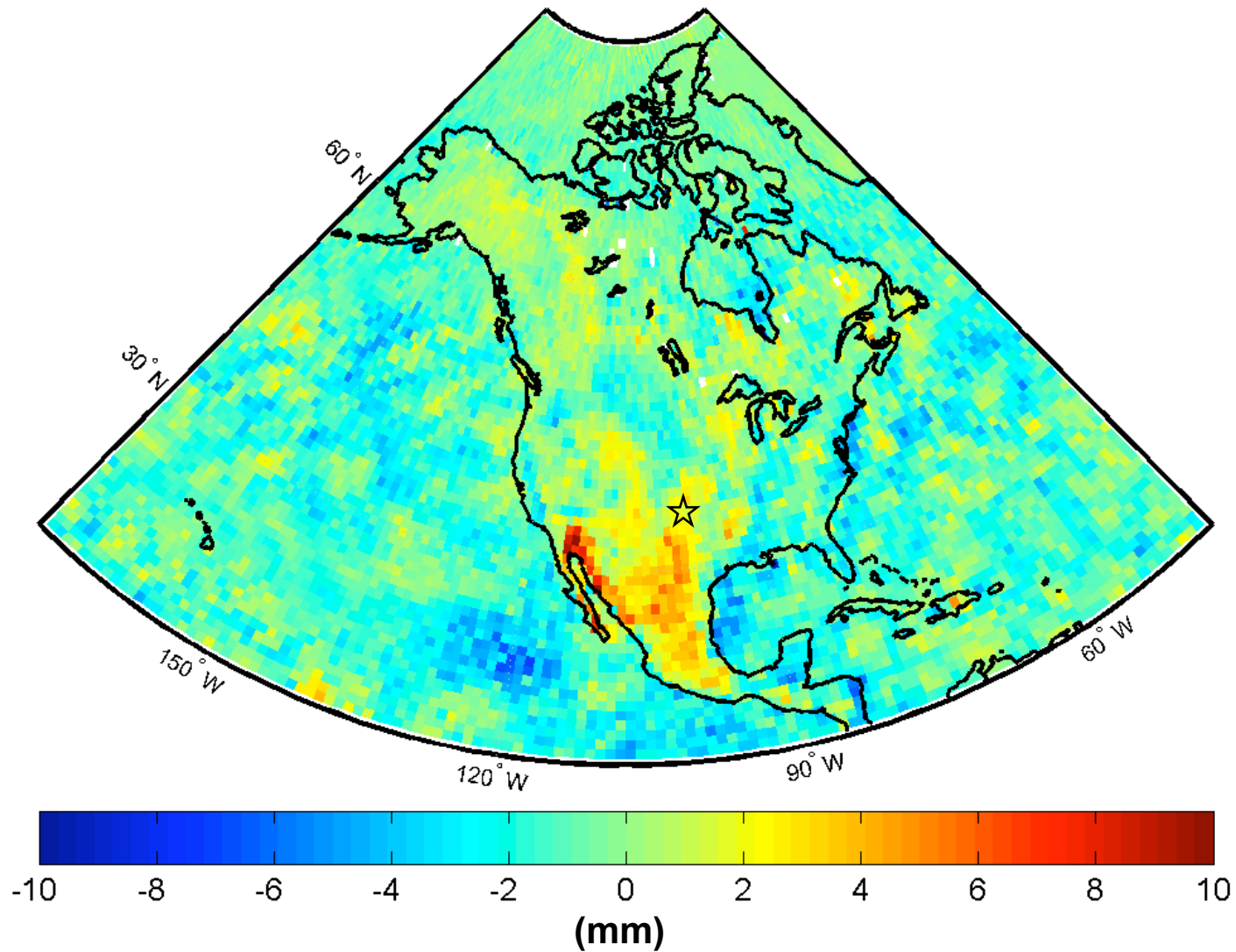


AIRS V5.0

September 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.09

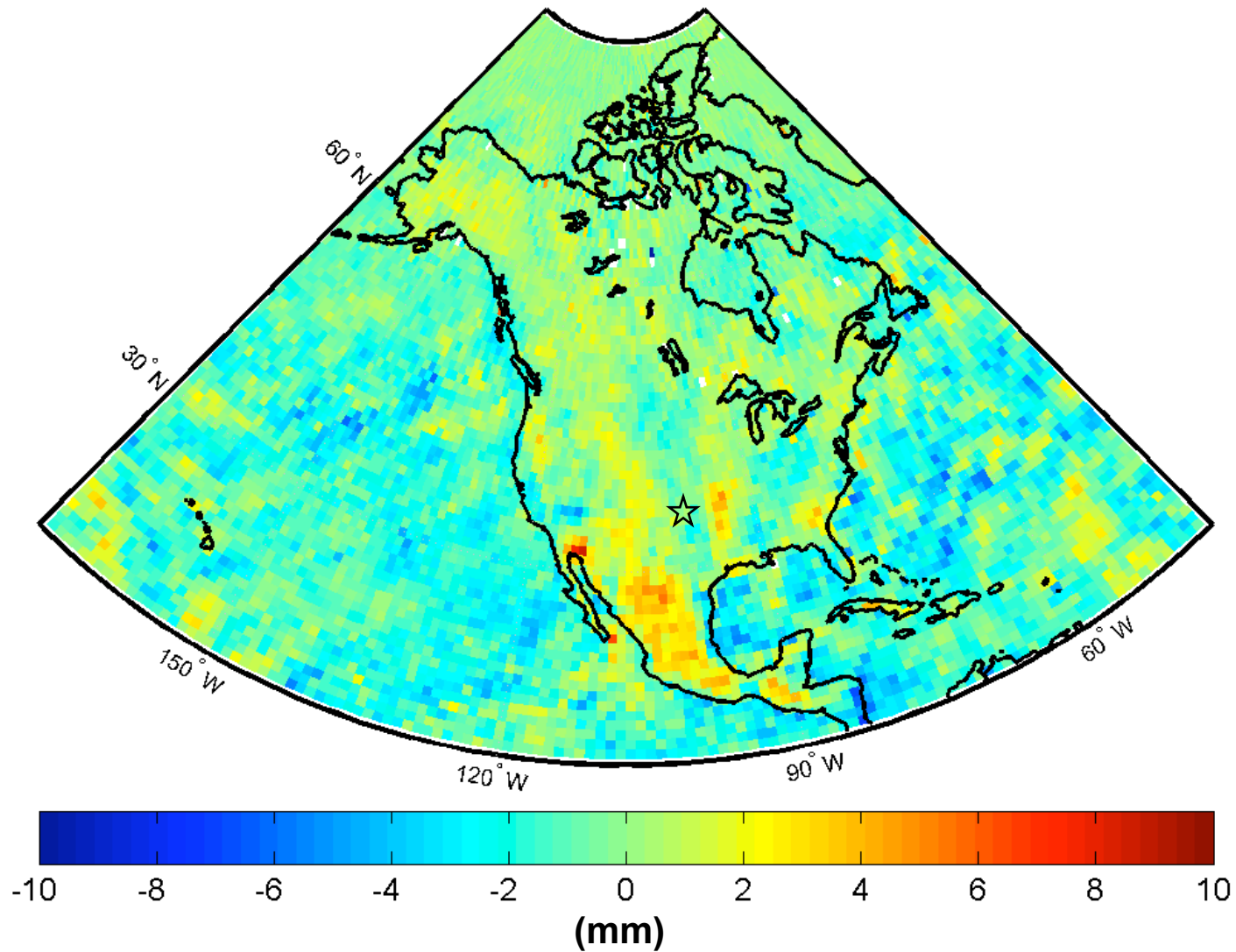


AIRS V5.0

October 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.10

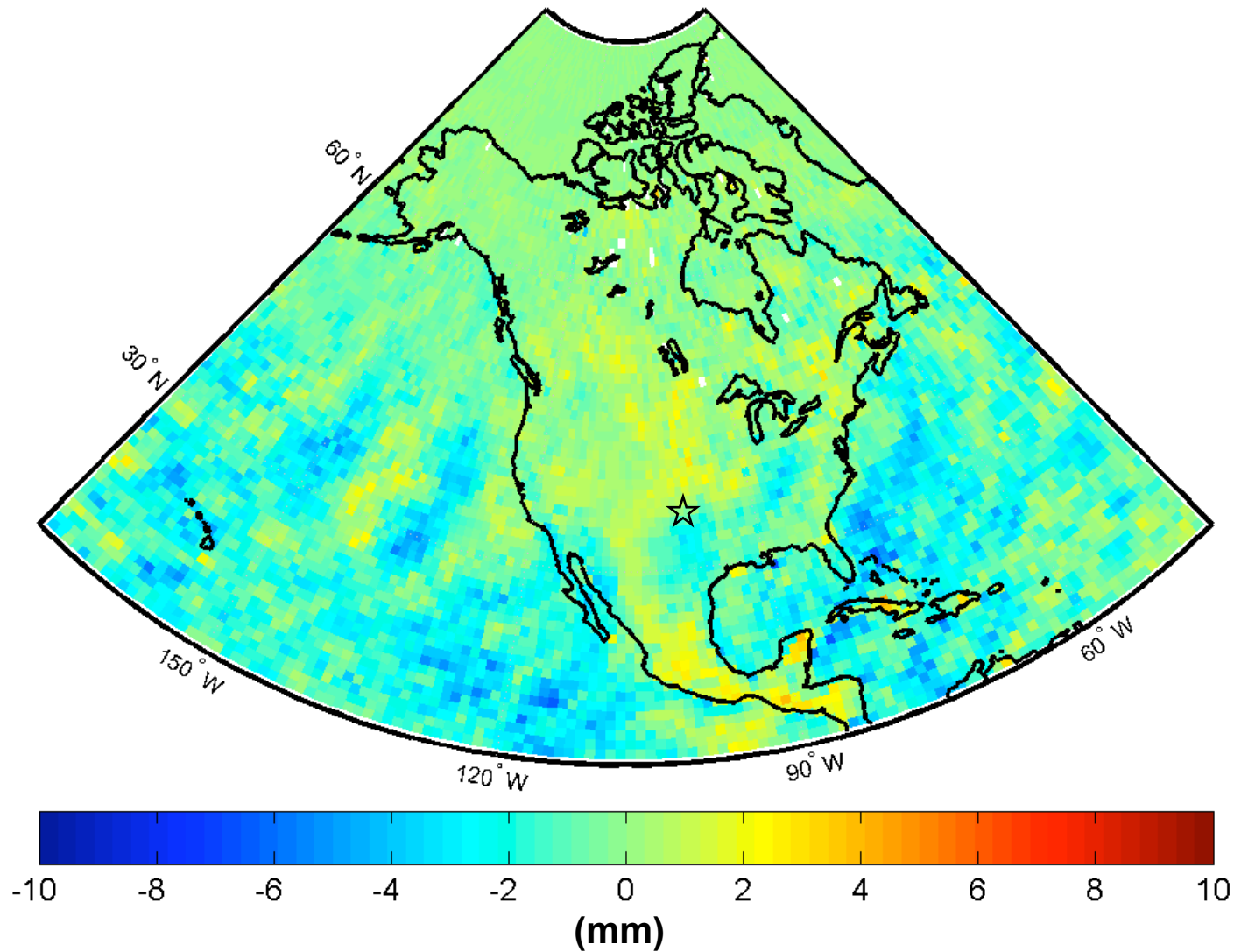


AIRS V5.0

December 2003

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2003.12

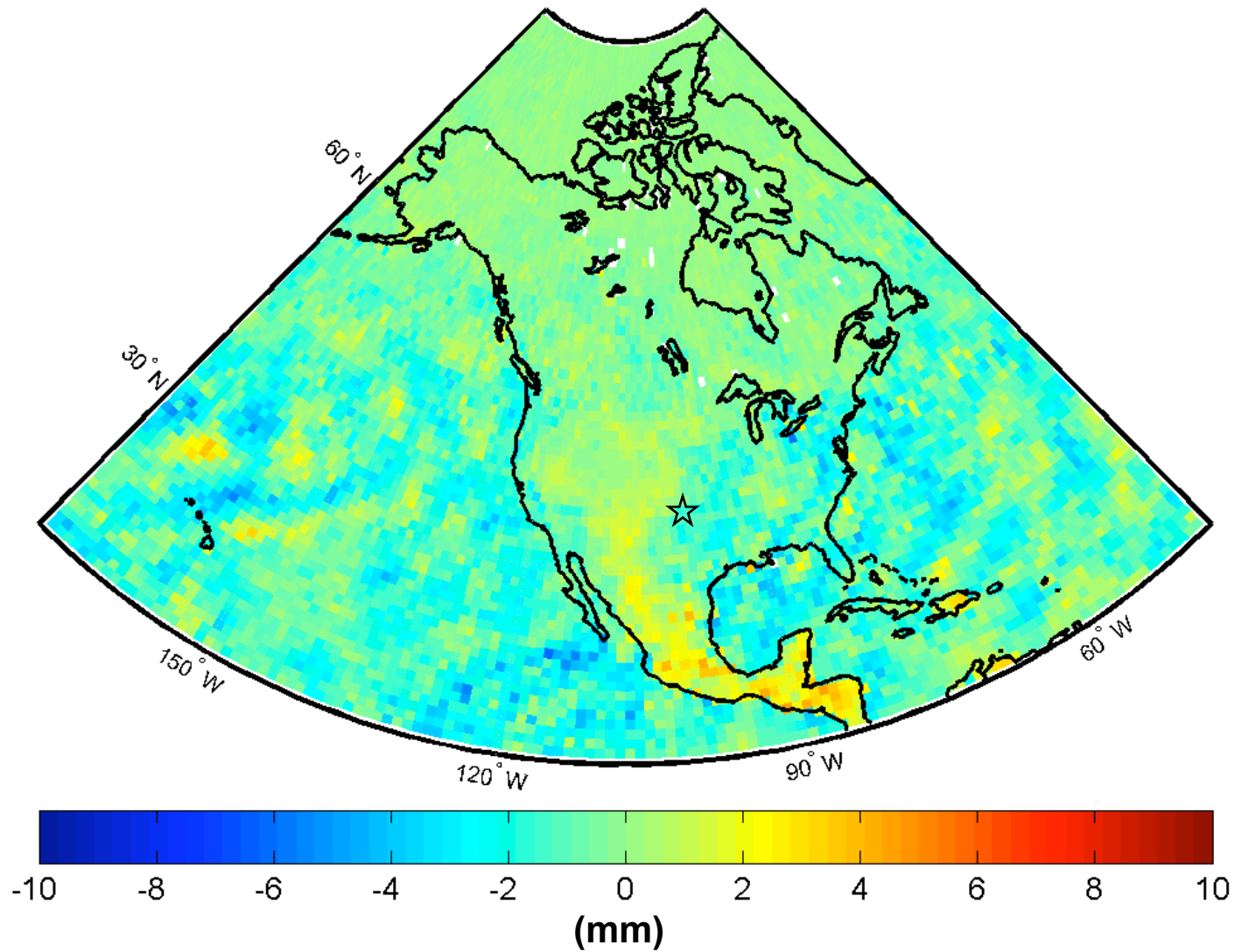


AIRS V5.0

January 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.01

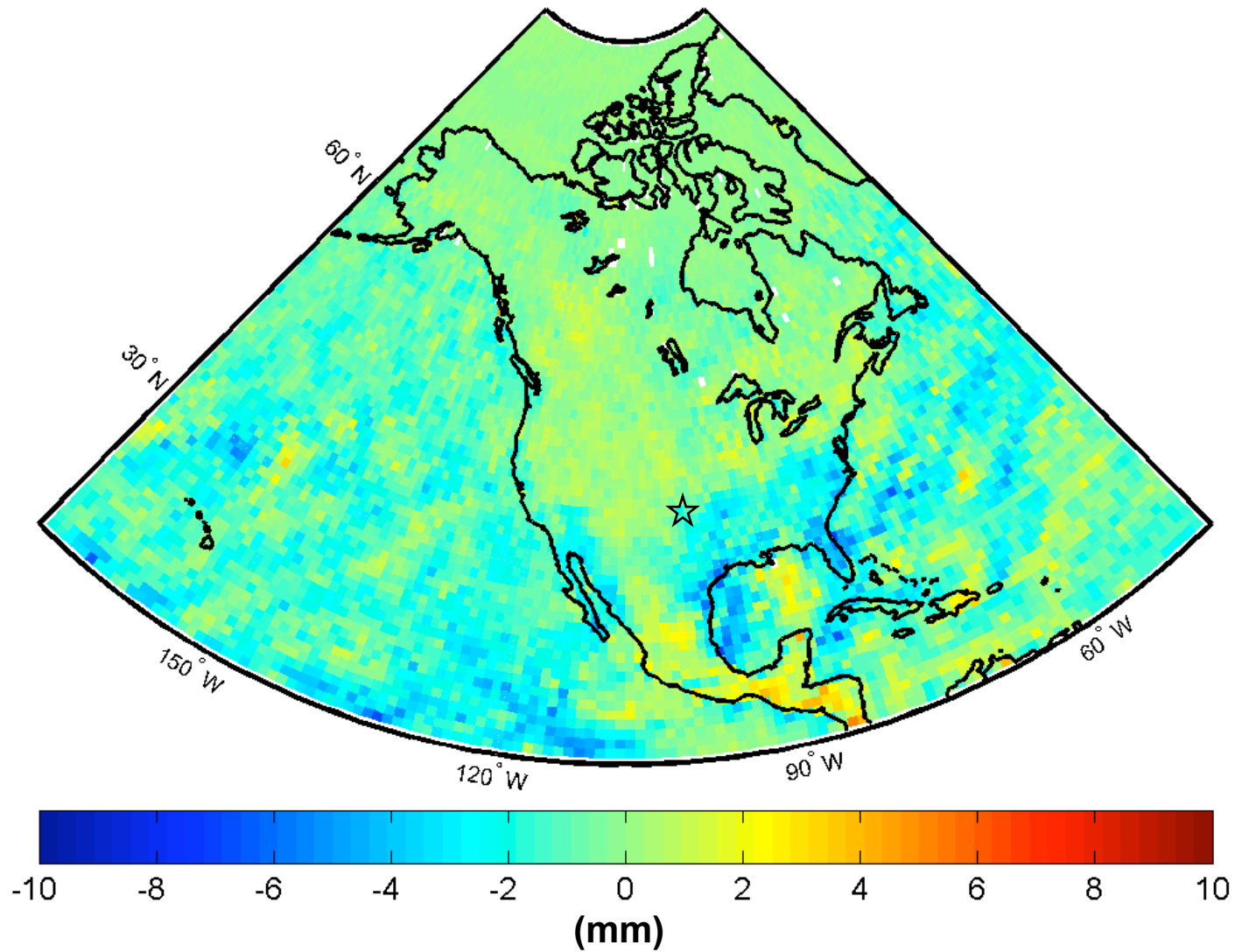


AIRS V5.0

February 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.02

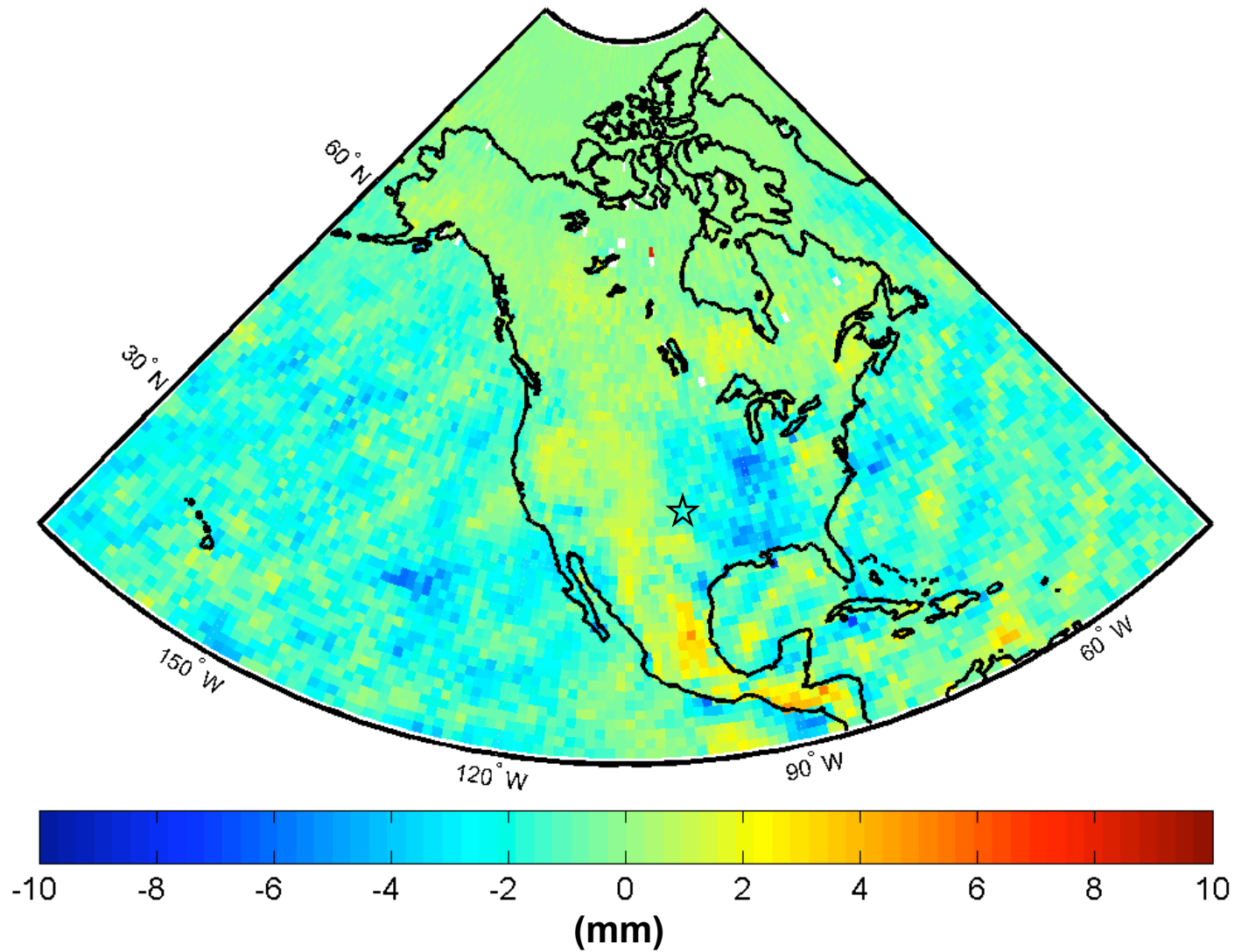


AIRS V5.0

March 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.03

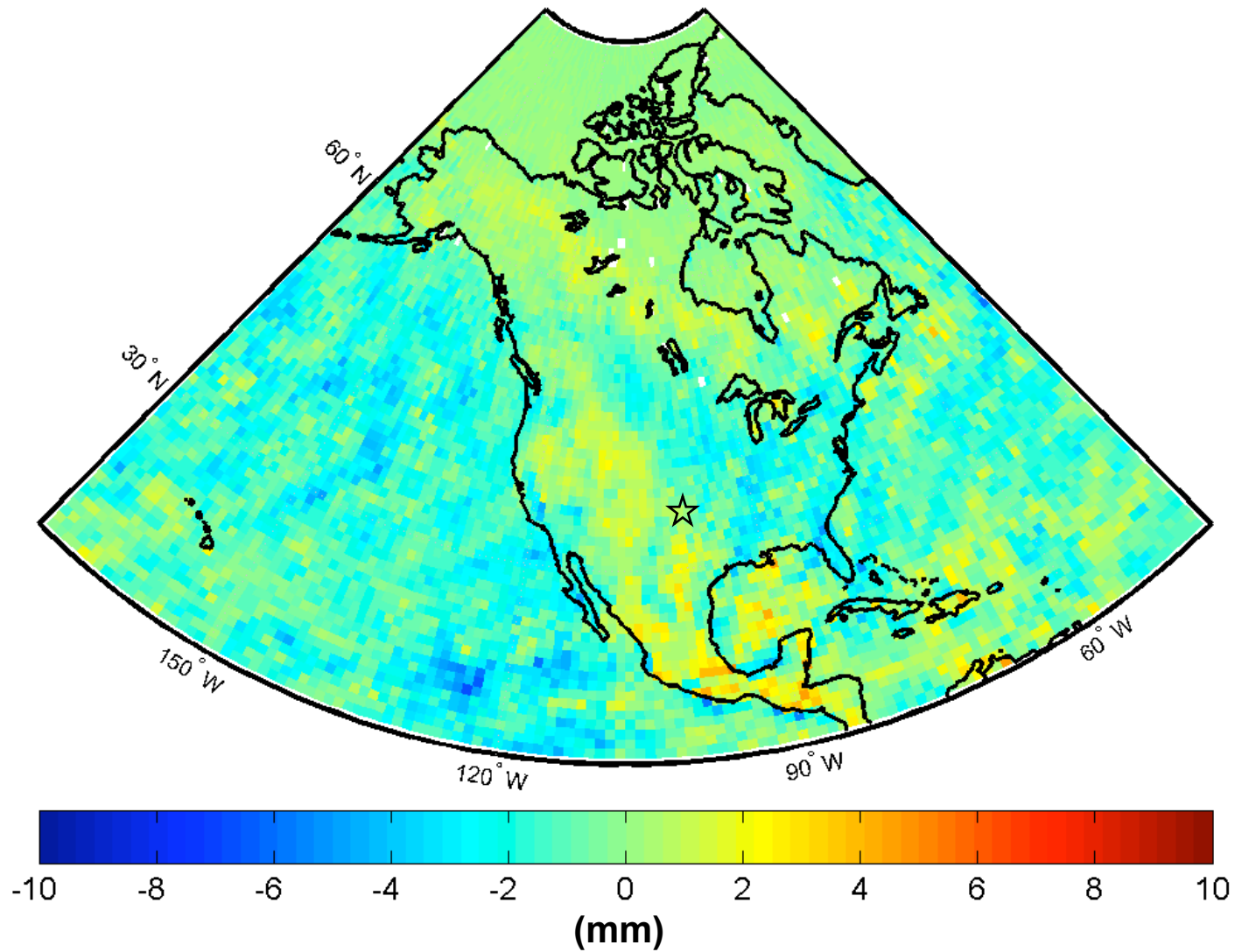


AIRS V5.0

April 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.04



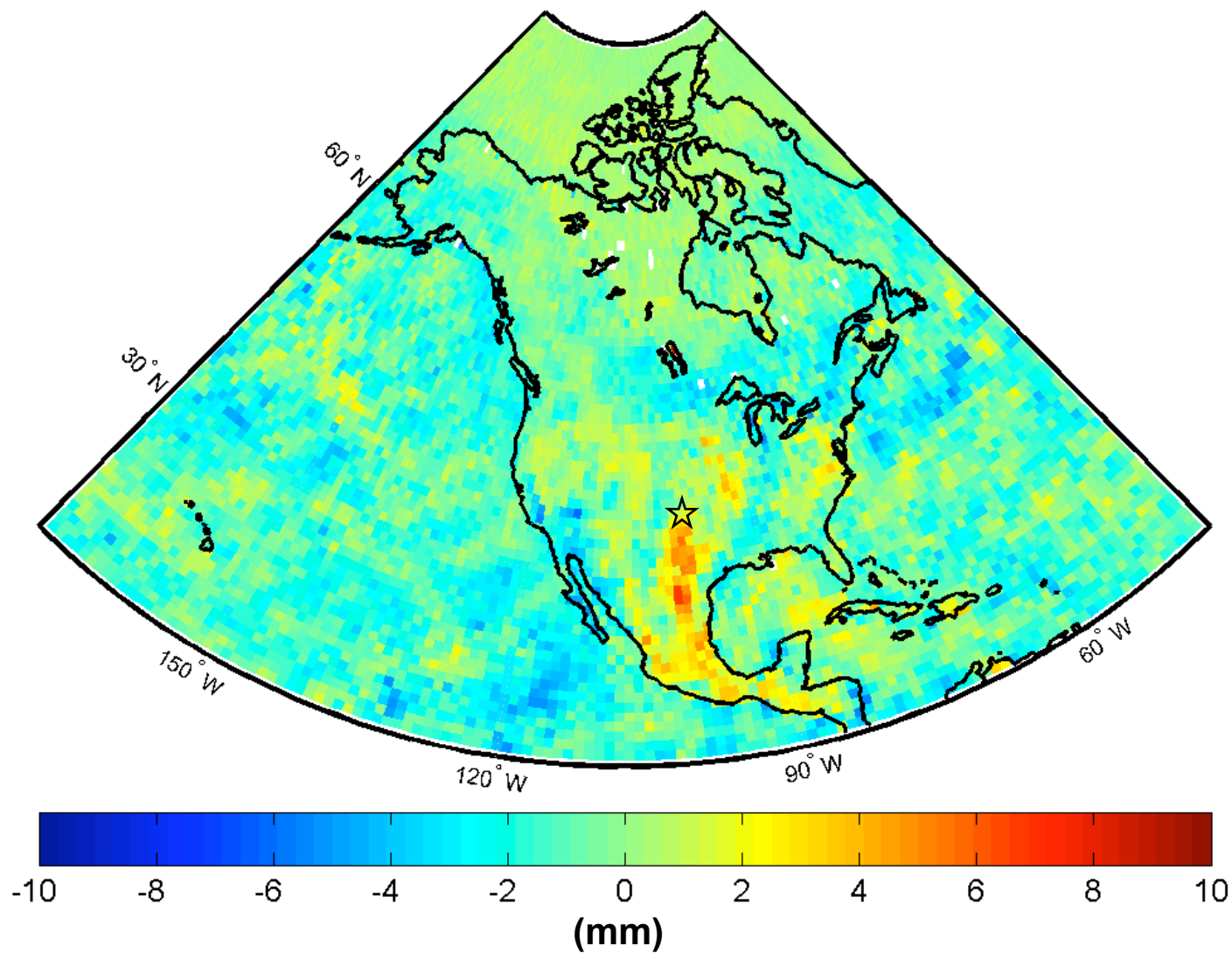
AIRS V5.0

May

2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.05

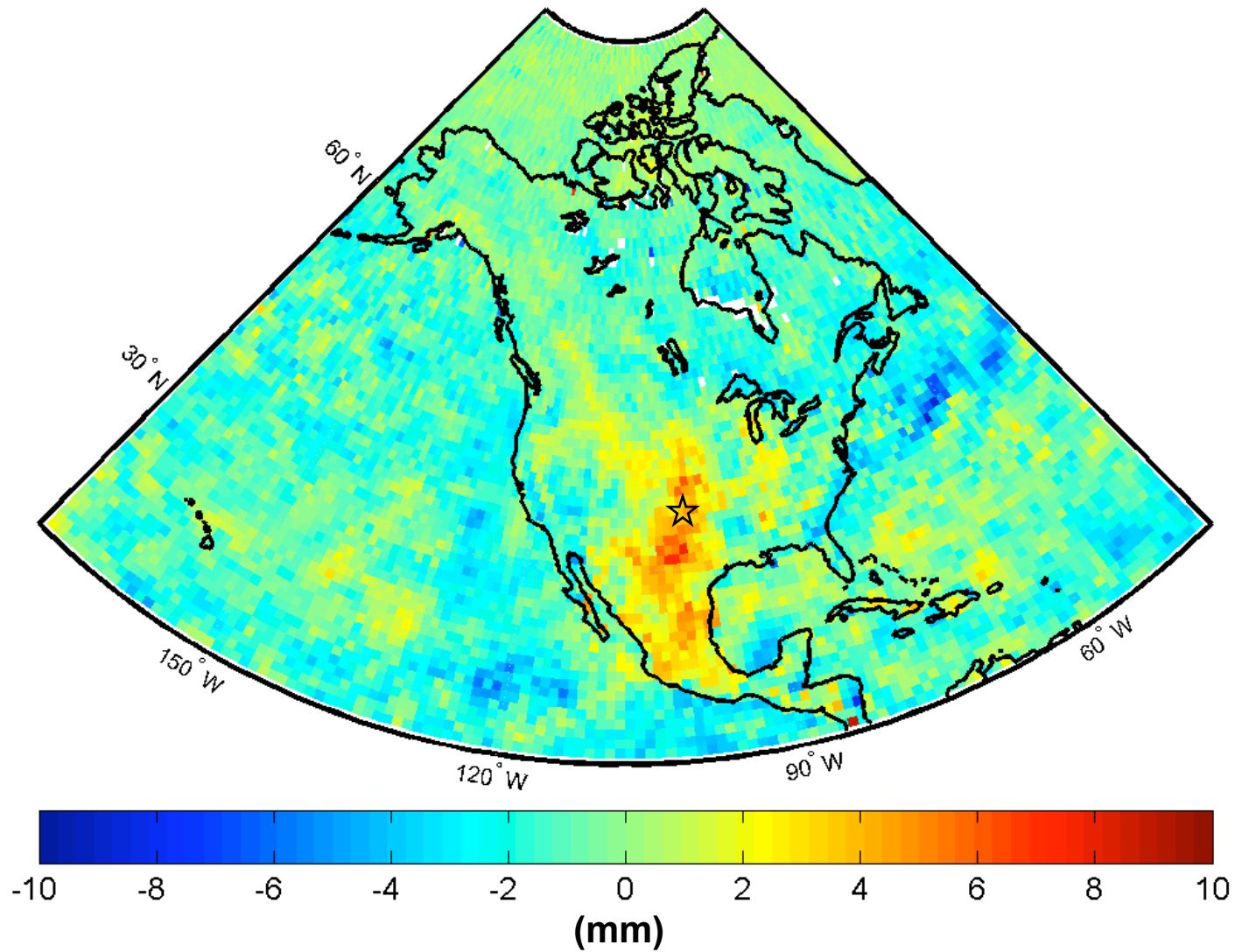


AIRS V5.0

June 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.06

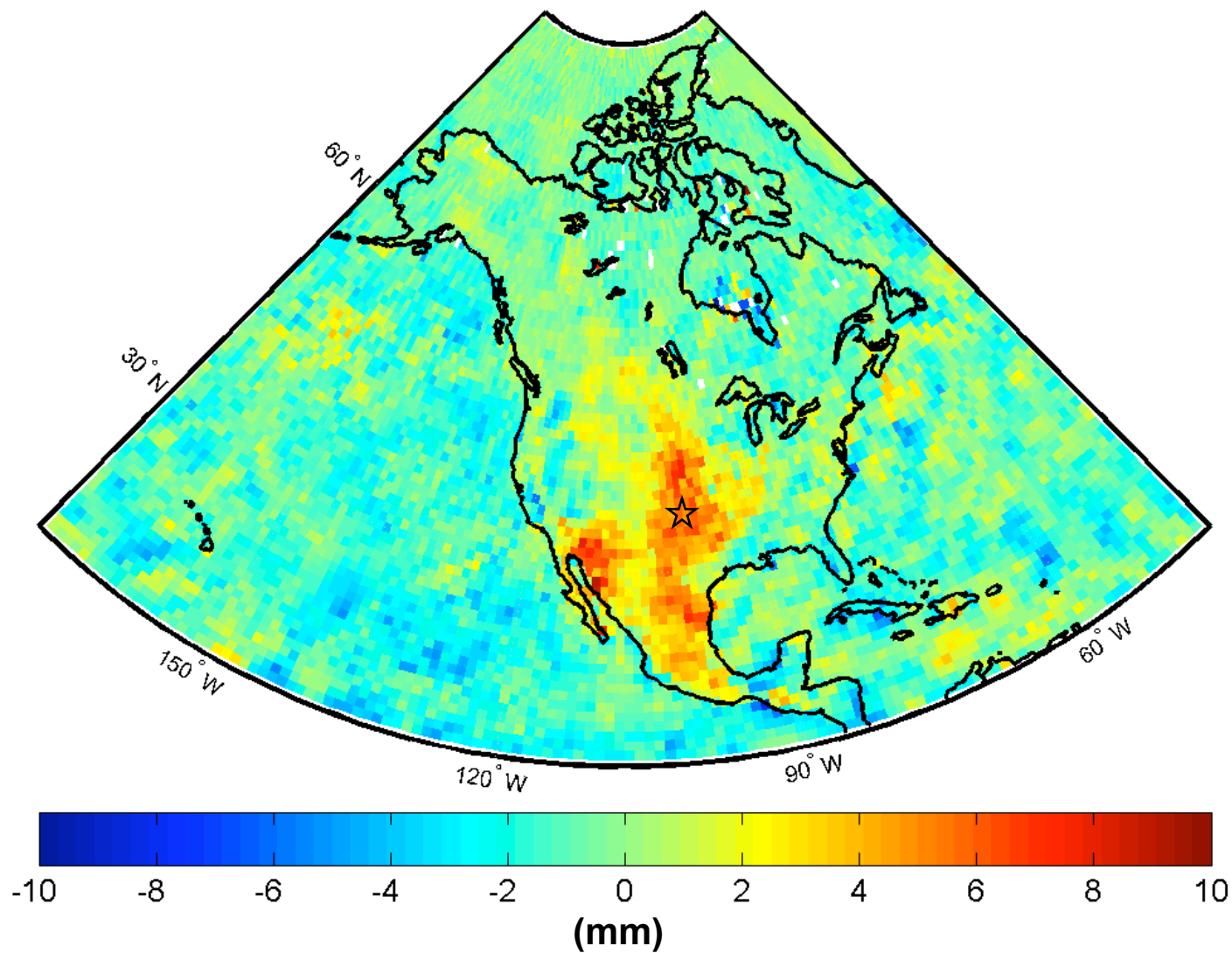


AIRS V5.0

July 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.07

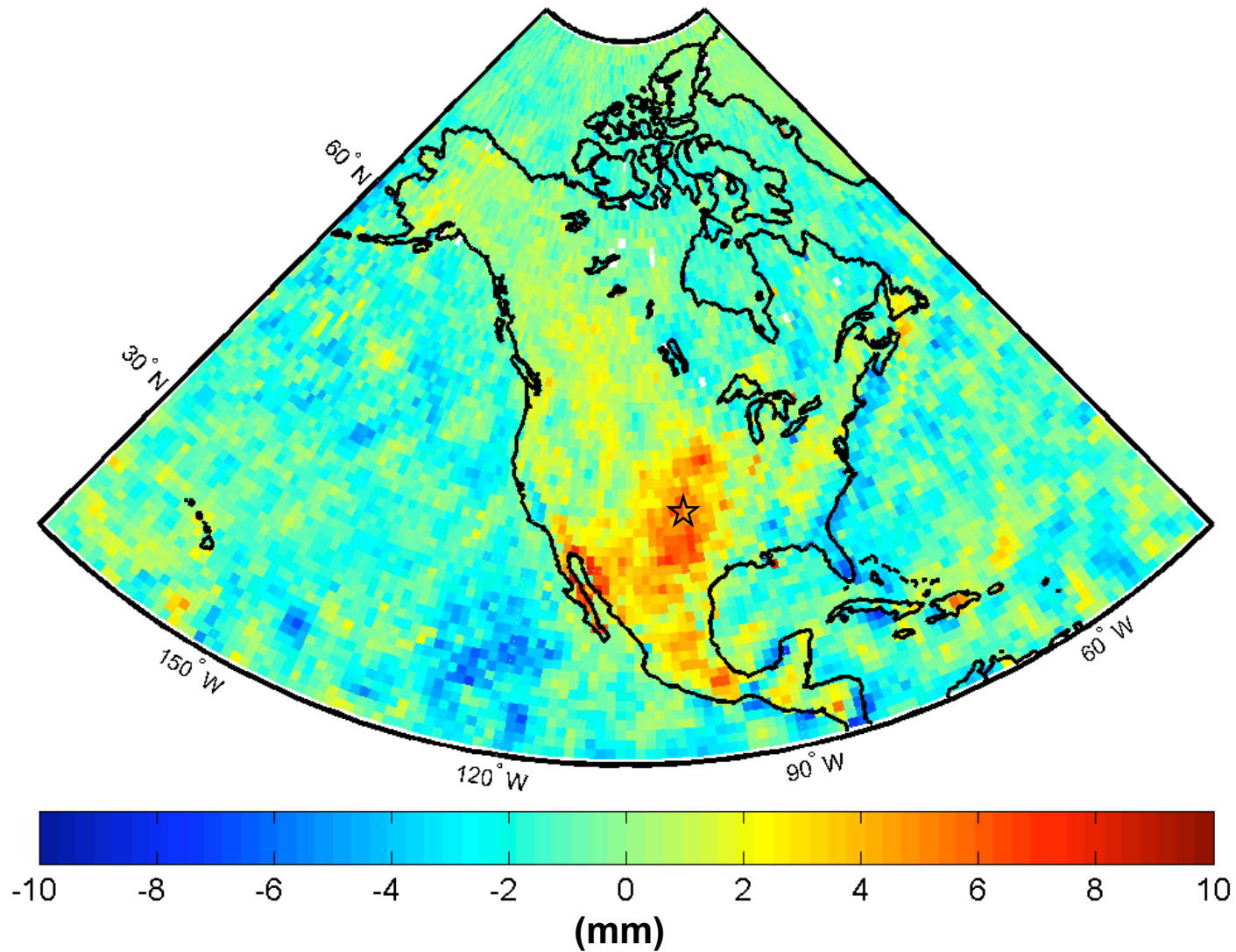


AIRS V5.0

August 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.08

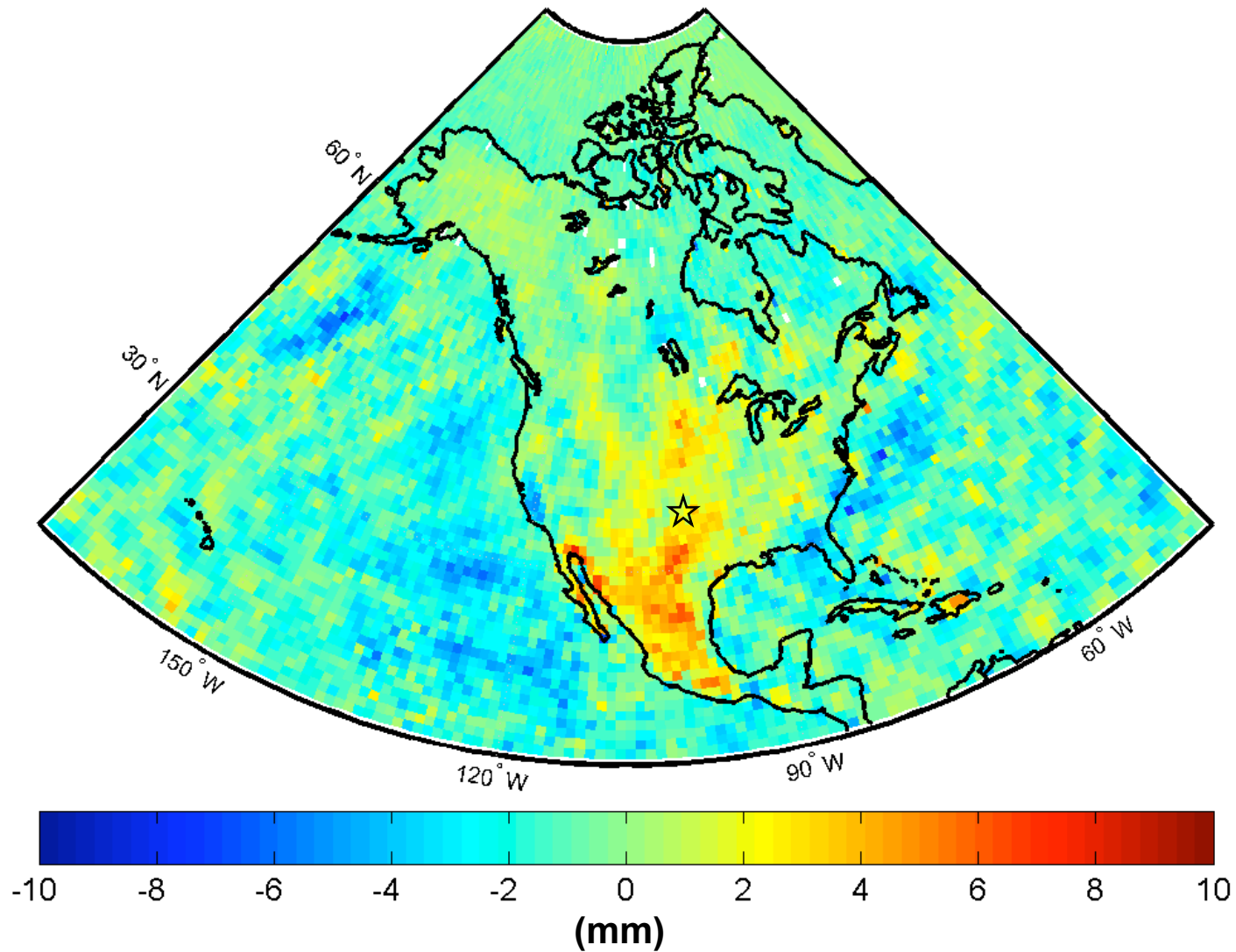


AIRS V5.0

September 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.09

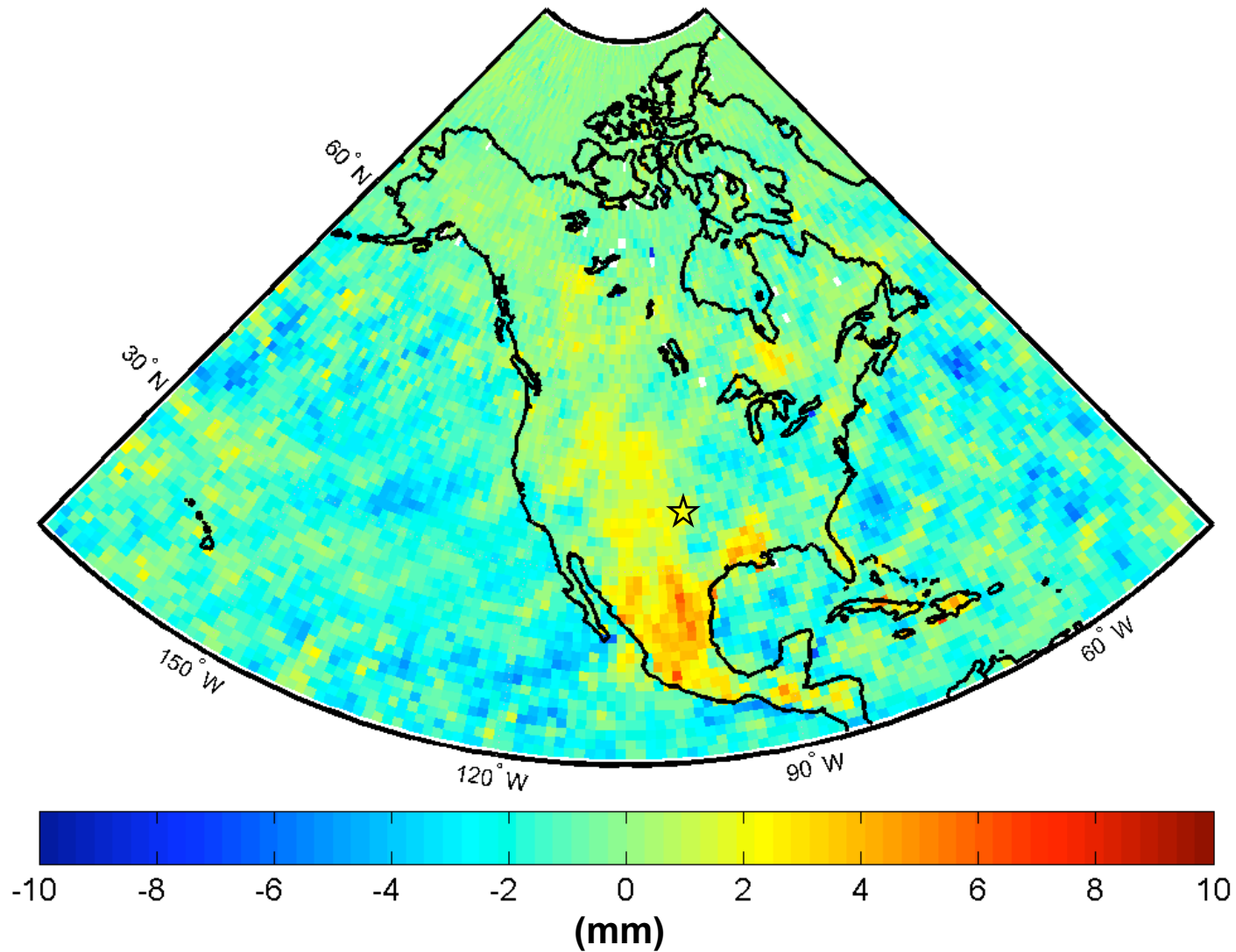


AIRS V5.0

October 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.10

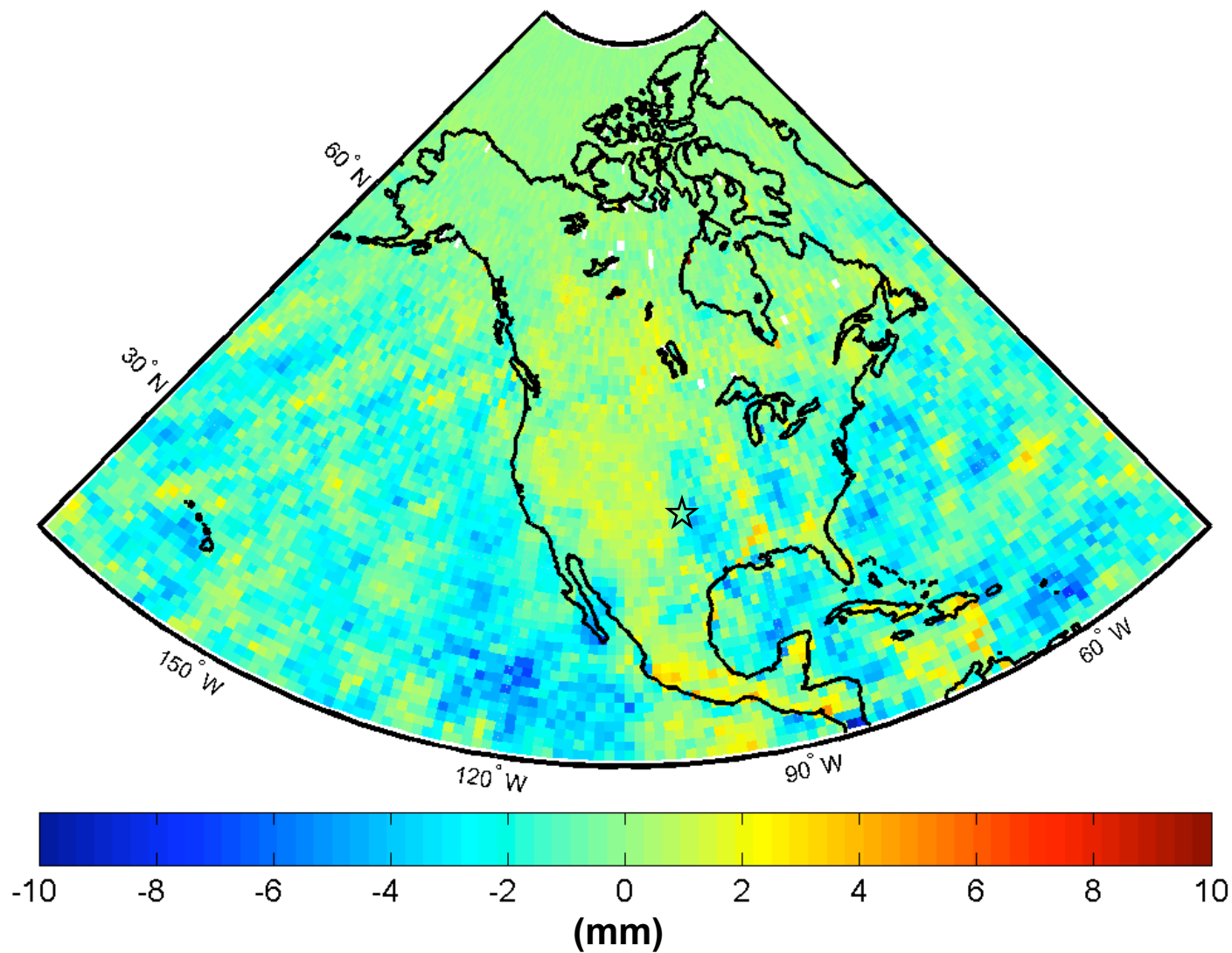


AIRS V5.0

November 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.11

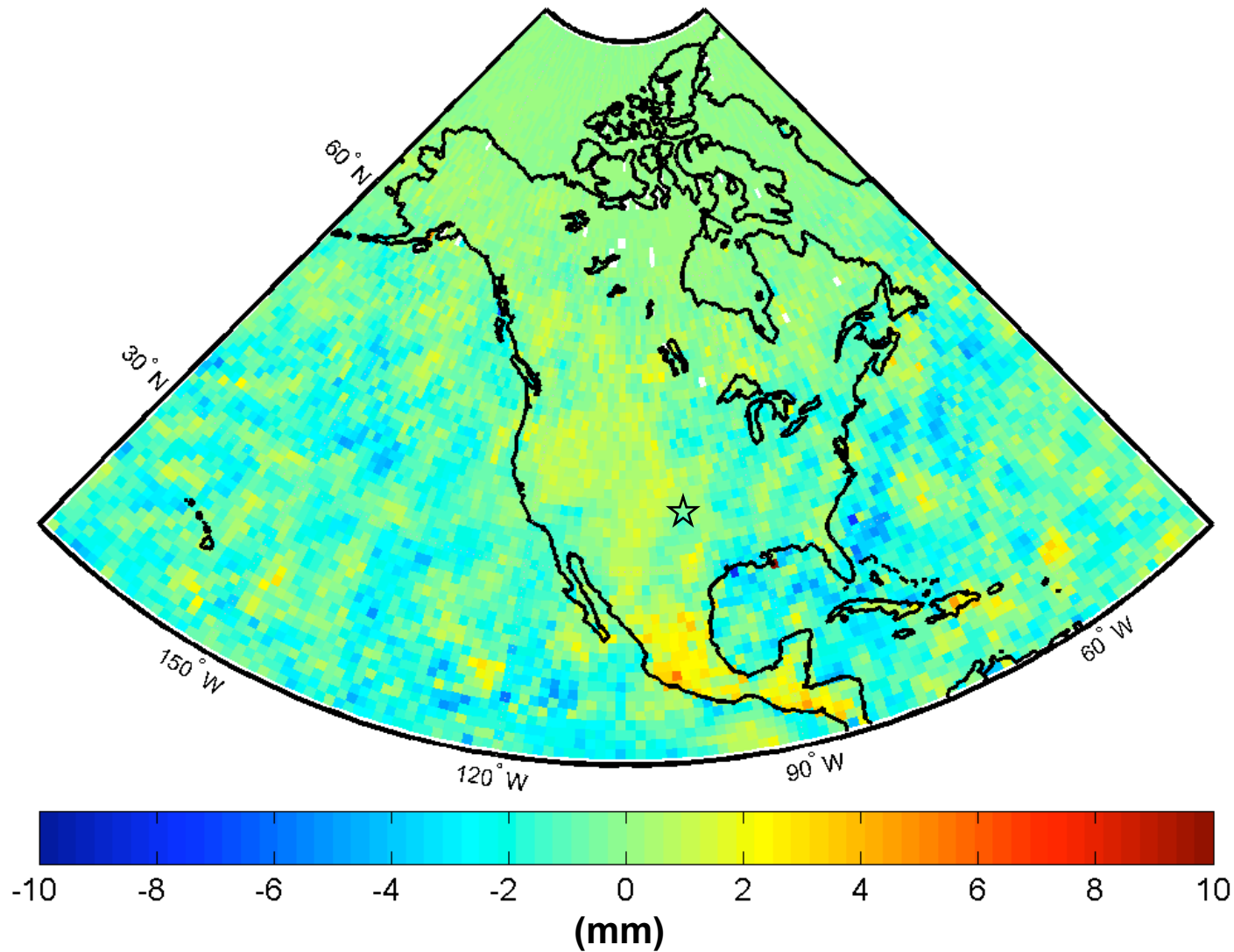


AIRS V5.0

December 2004

Day - Night

AIRS Total Water Vapor DAY minus NIGHT (mm H₂O): AIRS.2004.12



Questions regarding the AIRS TPW Day/Night Bias:

- Day/night monthly bias appears to have a consistent seasonal and geographic variation pattern. One of the strongest signals is observed to be in the U.S. Great Plains centered at the DOE ARM SGP site where we have the most accurate ground-based instruments.
- What physical mechanism leads to this monthly day/night bias in “tornado alley”? Is this day/night bias a candidate for a potential climate signal that AIRS could help quantify over a decadal time periods?
- Is this a real signal or a measurement artifact? Could there be a retrieval loss of sensitivity to boundary layer water vapor due to night time temperature inversions?
- What is the climate quality of the AIRS TPW product in terms of absolute accuracy of total water amount?

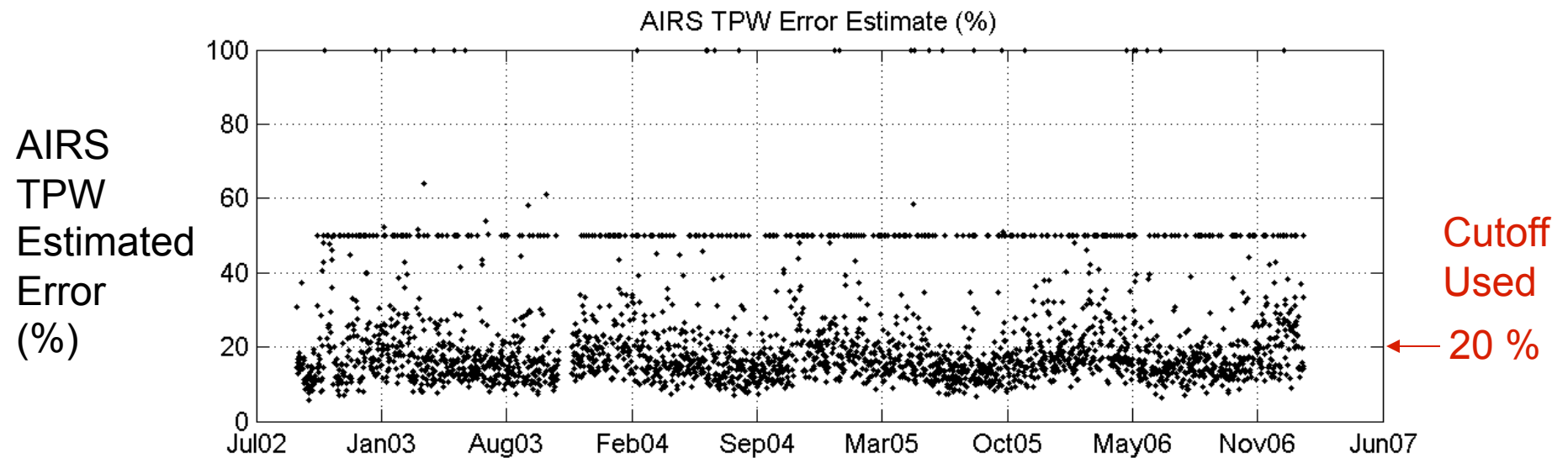
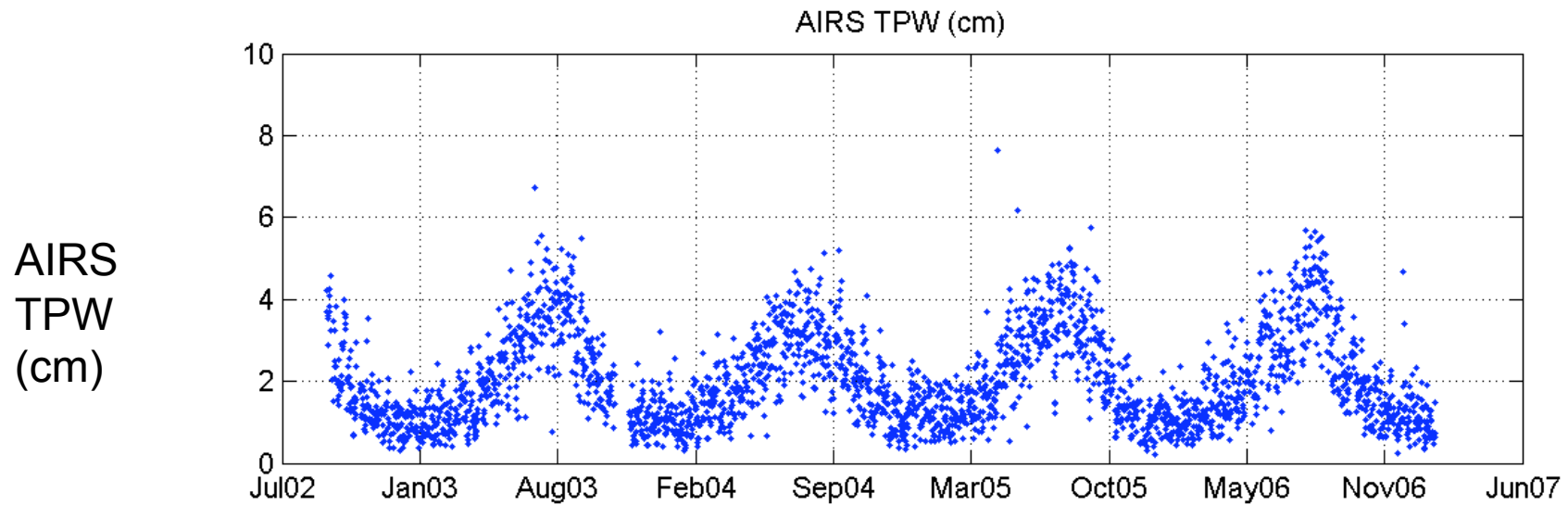
22 GHz MWR Retrieval of TPW (built by Radiometrics, Inc.)



- Radiometrics, Inc MWR calibration accuracy is about 1%.
- 22 GHz spectroscopy known to better than 1% (Clough et al., 1973 Stark Effect paper)
- TPW “best estimate” retrieval method used to analyze ARM time series by Dave Turner (Turner et al., 2007)
- Water Vapor Intensive Periods connected Chilled Mirror (better than 1%) to MWR column using Raman Lidar (Revercomb, Melfi, Whiteman, et al., 2003)

Conclusion is that absolute accuracy is about 2% ($k=1$)

AIRS TPW for ARM SGP Site Matchups



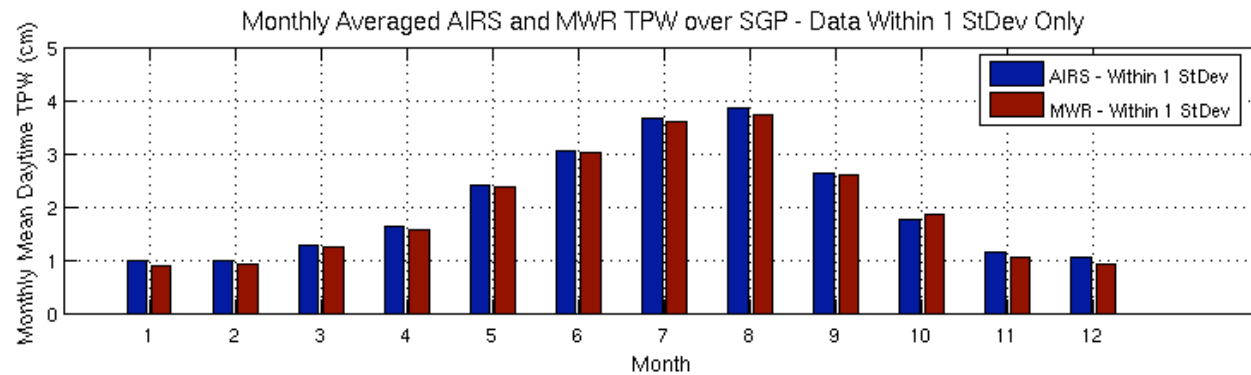
SGP

AIRS
(blue)

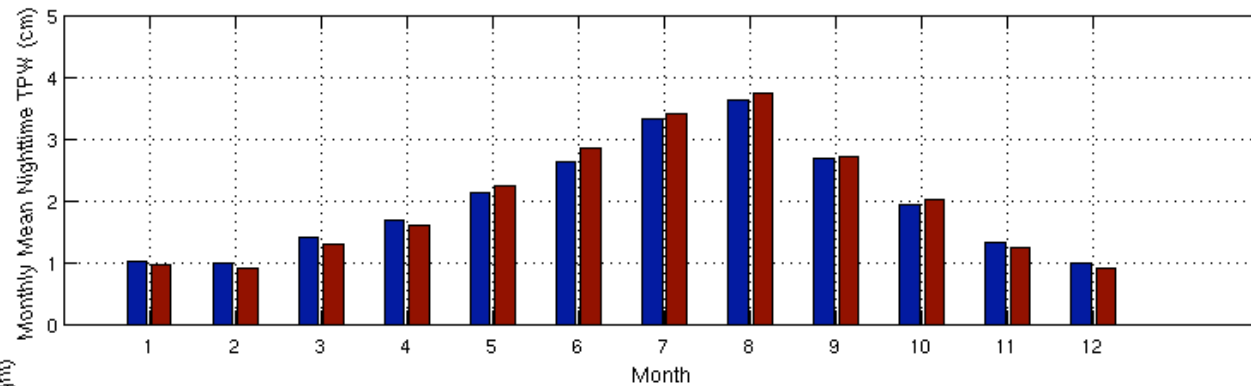
MWR
(red)

AIRS
Over-
Estimates
Diurnal
TPW
Signal
MJJA

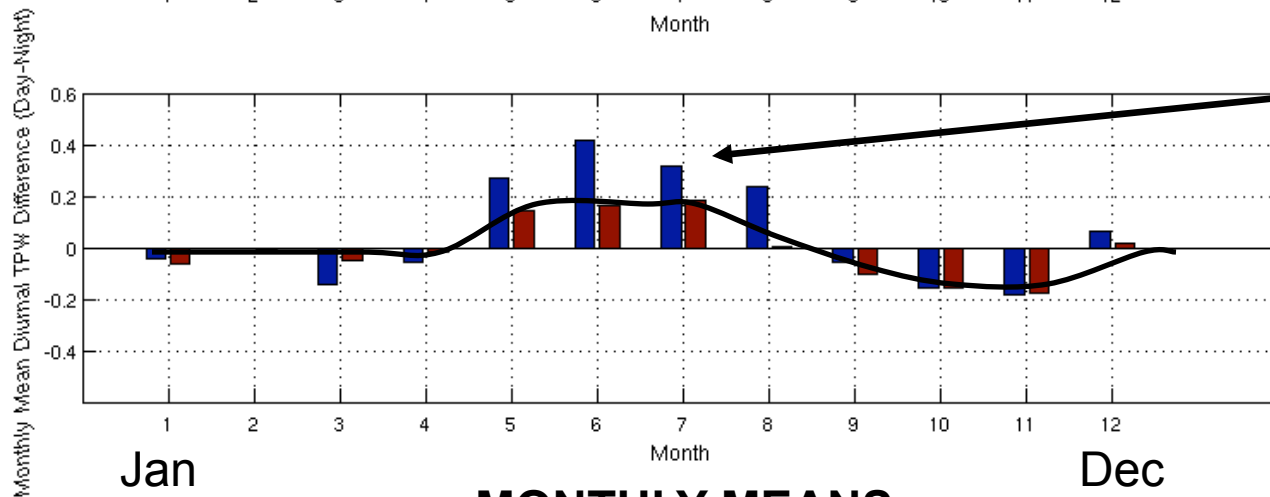
Day



Night



Day-
Night



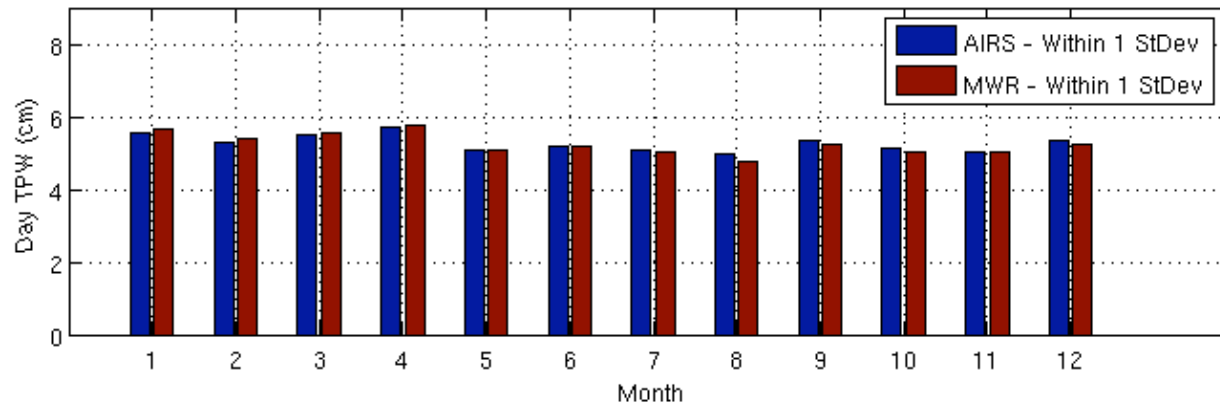
MONTHLY MEANS

SGP MWR validation shows there is a seasonal signal in the day/night AIRS bias but there is also an overestimate in the summer months which is unexplained.

What about the ARM Tropical Western Pacific site at Nauru on the equator? Does that site show day/night biases? (answer is no)

Monthly Mean AIRS and MWR TPW over TWP - Data Within 1 StDev Only

Day

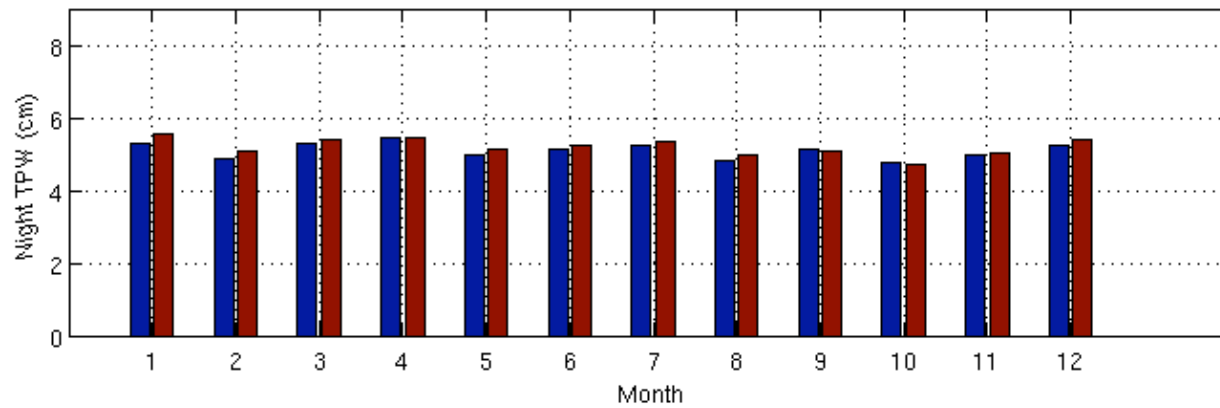


TWP-NAURU

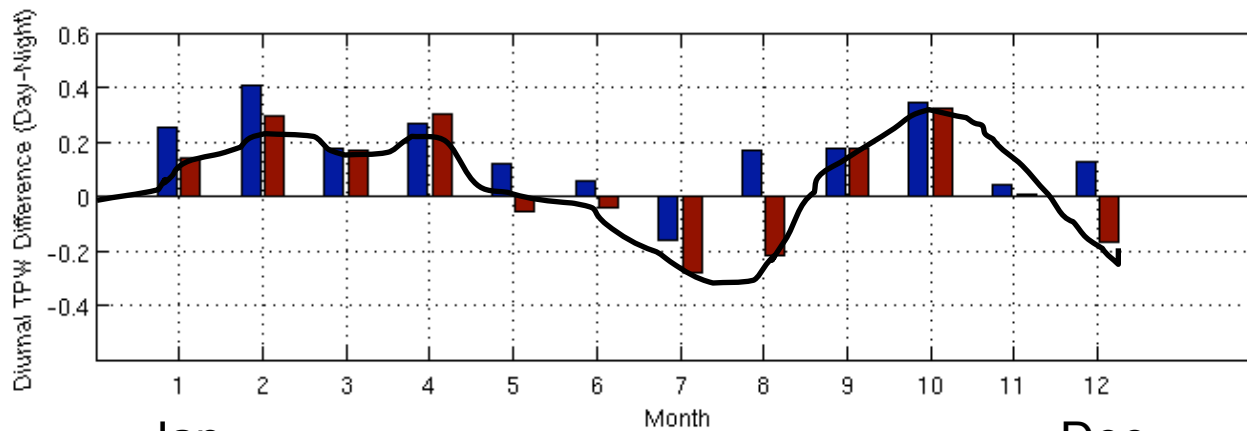
AIRS (blue)

MWR (red)

Night



Day-Night



AIRS Tracks MWR Fairly Well

Jan

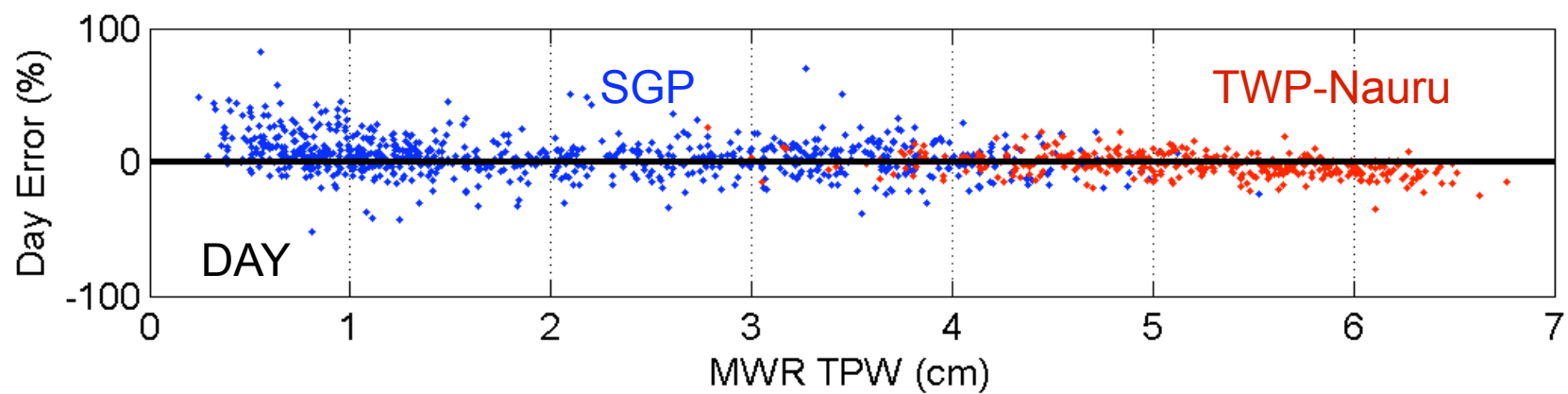
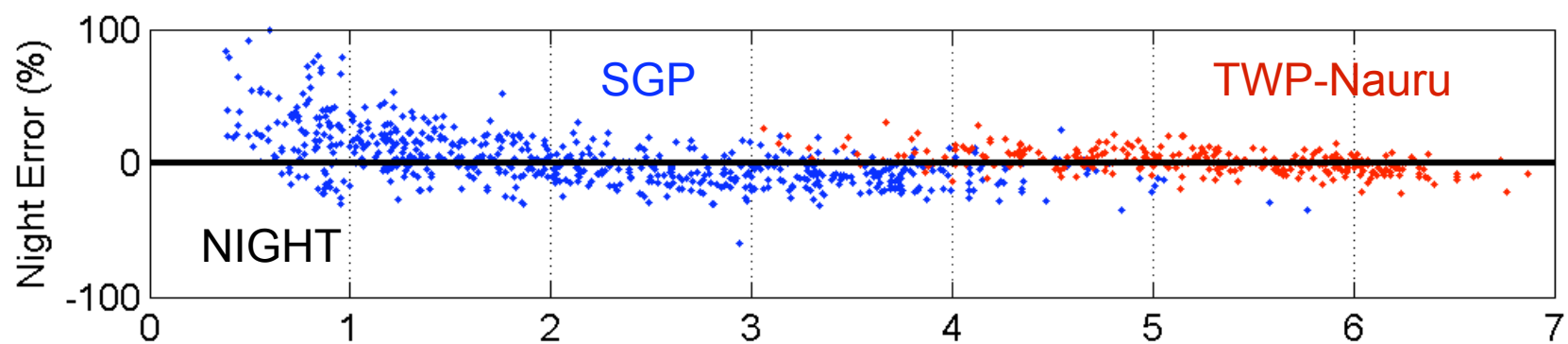
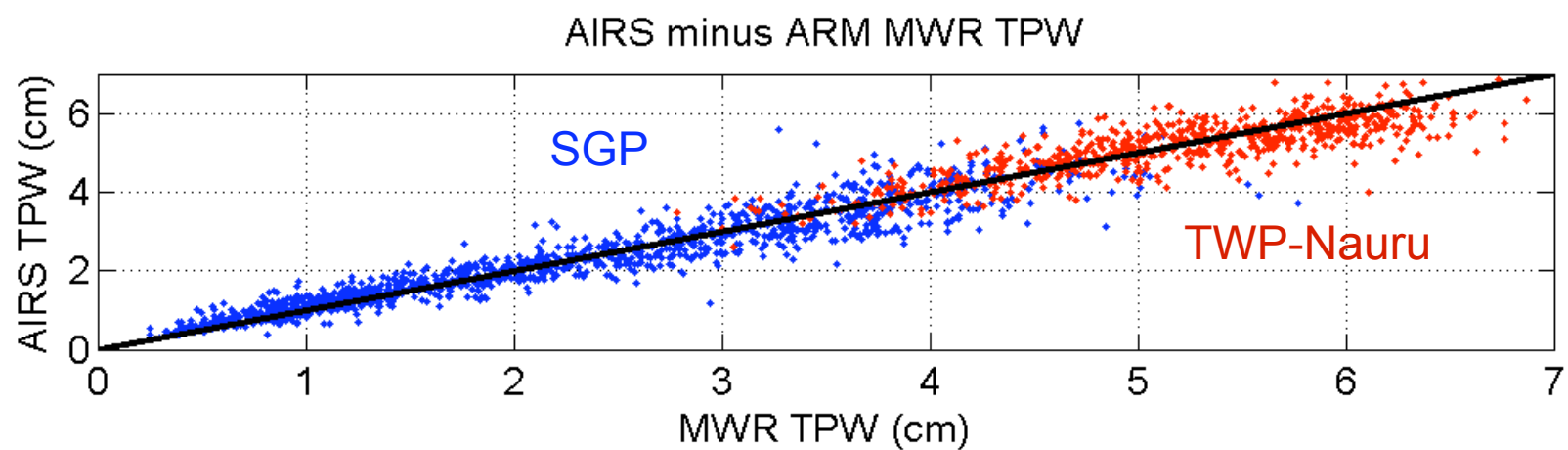
Dec

MONTHLY MEANS

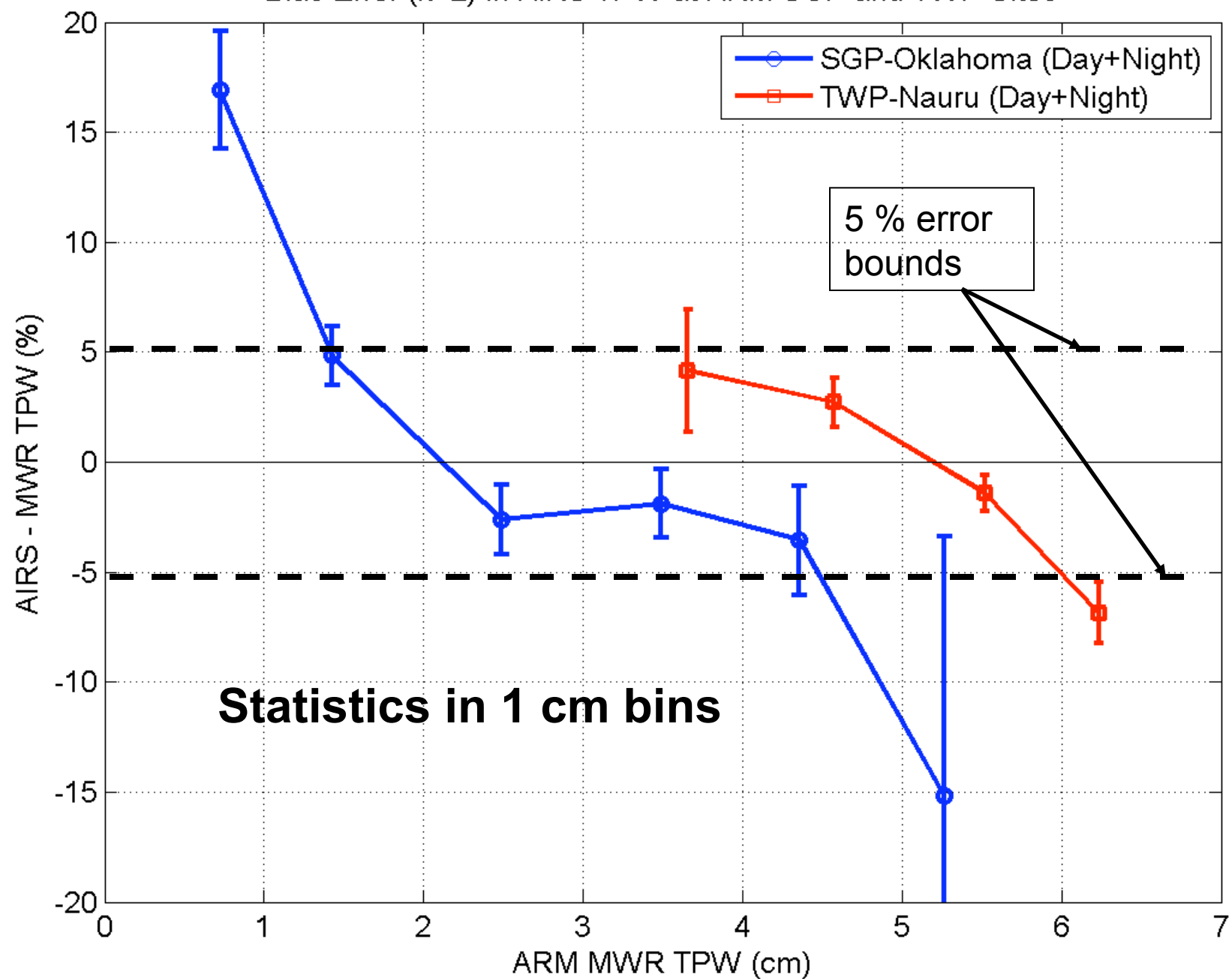
AIRS TPW Validation at ARM SGP and TWP-Nauru Sites (0.5 to 6.5 cm range)

Criteria Used in TPW validation:

- Closest AIRS Field of Regard to the ground site
- AIRS estimated error must be less than 20%
- MWR TPW temporal variability less than 2%
- Matchups between September 2002 and January 2007
- Approximately 3600 match-ups in all.
(2600 SGP + 1000 TWP-Nauru)



Bias Error (k=2) in AIRS TPW at ARM SGP and TWP Sites



Summary: AIRS TPW V5 Validation

- Day/night monthly bias at the SGP is about a factor of two higher in summer months than observed in the MWR ground-based data. This should be investigated further with regard to climate impacts.
- AIRS total precipitable water vapor is within 5% absolute uncertainty for amounts greater than 1 cm. Indication of a larger error (about 15%) for amounts less than 1 cm.
- Future work includes evaluating the AIRS TPW for very low water amounts at the ARM North Slope of Alaska ($\ll 1$ cm).